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University of Huddersfield

School of Music, Humanities and Media

Department of Music

Thick Relationality

Microtonality and the Technique of Intonation in 21st Century String Performance

Mira Benjamin

Submitted in partial fulfilment of the requirements for the degree of
Doctor of Philosophy in Music, January 2019.

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Abstract

This practice research explores the relationship between *intonation* and *microtonality*, and questions how these approaches to understanding musical pitch can relate to one another in 21st century string performance. Drawing on elements of historical and contemporary string technique, current debates on Artistic Practice as Research, an evolving discourse surrounding *embodiment*, and my own creative practices of playing and teaching, this research develops a relational epistemology of musical pitch via various ways of modelling, practising, representing, and ultimately *knowing* pitch.

The outcomes of this research are presented in seven *Instances of Practice*, a phrase chosen in place of the more conventional 'case study' in keeping with this project's core principle that embodied practice is *epistemic*, being 'structured by and productive of knowledge' (Spatz, 2015: 26). The accompanying portfolio, comprising six audio recordings and an original teaching resource, reflects discovery-led accounts of specific instances where *embodied knowledge* has been put to use in the practice of experimental music for solo violin and small string ensemble.

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Some cherished colleagues have made this not just a project but a life—my thanks to: Anton Lukoszevieze and the members of Apartment House for quality music making and always broadening my horizons; Simon Reynell for so many wonderful collaborations and for all you do for experimental music; the members of the Bozzini Quartet for opening my ears to these sounds in the first place. For their contributions to my portfolio of creative practice I thank: Martin Arnold, Chiyoko Szlavnics, Howard Skempton, James Weeks and Scott Mc Laughlin for composing such good reasons for me to play, and John Cage for… well, giving them such a good reason to compose.

Heartfelt gratitude to the University of Leeds Ensemble Performance students, who were generous and willing participants in this project, and to my students at Goldsmiths, who fill each day with discovery. They, and I, benefit from the abundance of curiosity and passion for violin technique given by my own teachers, Denise Lupien and Taras Gabora.

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***

In memory of Bob Gilmore, who left us so much.

‘In this thick relationality, humanity attunes itself to its world.’

— Ben Spatz (2015: 31)

Introduction

This PhD portfolio explores the relationship between *intonation* and *microtonality*, and questions how these approaches to understanding musical pitch can relate to one another in 21st century string performance.

During my years with the Bozzini Quartet, an ensemble recognised as interpreters of what is frequently called 'microtonal' music, I spent a significant portion of my time considering the topic of intonation. In developing my practice of tuning complex intervals in, for example, the extended Just Intonation works of James Tenney, I became increasingly sensitive to intonation when rehearsing a quartet by Beethoven. Simple, diatonic intervals became the focus of obsessive scrutiny, suddenly seeming to pose unresolvable intonation paradoxes and ultimately drawing the focus of many hours of rehearsal.

Soon, the casual arrows with which I noted the inflection of significant pitches in my performance scores were replaced by cent deviation annotations. Ratios, too, began to appear, amongst other strategies adopted from my practices of 'microtonal' music—efforts to reify an implicit sense of intonation into something concrete and reliable. I also noticed a friction emerging between my own subtly shifting embodied knowledge of musical pitch, and the signifiers with which I daily engaged in practice.

The power of a ratio (5/4) and a cent deviation (-14) to ground the intonation of a major third between myself and one of my colleagues could be suddenly thrown into flux when the slip of a finger by one or the other of us required real-time adjustments. The *technique* of tuning a pure third would invariably overtake its signifiers, which I came to believe held value not as reifications but rather, to borrow a term from social anthropologist Clifford Geertz, as *thick descriptions*[1] of something that I was *doing.* The question of *what* I was doing was enough to motivate this research.

[1] Thick description (Ryle, 1949; Geertz, 1973) 'refers to the detailed account of field experiences in which the researcher makes explicit the patterns of cultural and social relationships and puts them in context' (Cohen & Crabtree, 2006). A thick description can be 'a way of providing cultural context and meaning that people place on actions, words, things, etc., [providing] enough context so that a person outside the culture can make meaning of the behavior' (Ray, 2011).

Objectives, Methodologies and Chapter Structure

The integrated practice research represented in this thesis and the attached portfolio of creative practices follow a 'discovery-led' (Bell, 2016: 19) approach adopted by a growing number of Artistic Research projects, which is not 'predominantly concerned with general methodological precepts or conclusions, or with divining law-like regularities in artist's behaviour, nor with arriving at binding judgements of taste in the aesthetic sphere' (Bell, 2016: 19). Running throughout all the components of this project are these questions:

> What is the relationship between *intonation* and *microtonality*, and how can these approaches to understanding musical pitch relate to one another in 21st century string performance?
>
> What is a *technique of intonation* and how may this area of *embodied knowledge* be directed in *practice*?
>
> How can string players interact with systems of musical notation, and make informed choices in our practices of notated scores?
>
> How can these reflections on techniques and practices of intonation and microtonality be impactful in the performance and pedagogy of new music?

These questions are not those that initiated this research, but rather surfaced gradually through a patchwork of methodologies based in an essentially auto-ethnographic research strategy. Motivated by a desire to contribute something useful (for my own practice and that of others) yet fundamentally descriptive (that is to say, *non-prescriptive*) in nature, this research perhaps somewhat irreverently combines elements of common practice string technique, current debates on Artistic Practice as Research, an evolving discourse in the burgeoning field of *embodiment*, and my own daily practices of playing and teaching. Mixing like oil and water in a bucket I might call *epistemology of practice*—a phrase borrowed from the theatre practitioner and theorist Dr Ben Spatz, whose work has been a primary inspiration for my own—these reluctant components nonetheless suggest to me the potential for new ways of knowing my body, my instrument, and the music I play.

This thesis is structured in three Parts: *Five Chameleons* (Chapters 1 and 2), *Ways of Knowing* (Chapters 3, 4 and 5) and *Instances of Practice* (Chapters 6 and 7). Part 1 unpacks five

multivalent concepts essential to my integrated practice research—*intonation, microtonality, technique, practice, and research*—and establishes a statement of position at the intersection of current discourse on Artistic Practice as Research through a concise literature review.

Part 2 explores three contrasting yet ultimately complementary epistemologies of musical *pitch space*. Chapter 3 juxtaposes ways of modelling pitch relationships, outlining the derivation of various tuning systems (with a focus on *Pythagorean* and *Just* Intonation), and suggesting their potential application in various practices of string intonation. Chapter 4 undertakes a more substantial review of string technical and pedagogical literature, employing an informal thematic analysis (Braun & Clarke, 2006) to identify themes and patterns in the way a representative cross section of string author-practitioners reflect their practices of intonation through language. Three paradigms of string intonation technique are observed in the literature, and are reflected upon in light of the position on technique and practice established in Chapter 1. Components of an *Embodied Paradigm of Intonation Technique* are then proposed, drawing on aspects of conventional string intonation technique, as well as recent contemplations on *listening* and the *aural imagination*. Chapter 5 then considers the role of symbolic representation—both in the *notation* and *annotation* of musical scores—in embodied practice, rationalising my own use of score annotation in the portfolio discussions which comprise the final two chapters.

Part 3 presents seven *Instances of Practice*, a phrase chosen in place of the more conventional 'case study', in keeping with this project's core principle that embodied practice is *epistemic*, being 'structured by and productive of knowledge' (Spatz, 2015: 26). I view my own creative practices, here represented by six audio recordings and an original teaching resource, neither as complete (although all have been published or presented in public spheres) nor as self-contained assertions of my artistic perspective.

My creative practice, like any other, is in flux, and, as it is represented here, reflects a shifting, malleable, still-amassing knowledge. The documented practices that comprise my portfolio thus reflect specific instances where *embodied knowledge* has been instantiated (as expanded upon in Chapter 1). At the same time, the propositions and positions being submitted here have arisen from sustained, prolonged experience and consideration, and are broadly applicable across many potential future practices.

Experimental Music and the Repertoire Elephant

Throughout this project, the elephant in the room has been my core repertoire, and the particular interpretive positions and freedoms afforded by it. I come to this research from a repertoire perspective that admittedly stands apart from many other contributors to the string intonation discourse. My practice is concentrated in what might broadly be called 'experimental music', a term with obvious ambiguities, but which has recently been clarified (at least in acknowledging its breadth) by Jennie Gottschalk, who writes:

> Experimental music is challenging to pin down because it is not a school or a trend or even an aesthetic. It is, instead, a position—of openness, of inquiry, of uncertainty, of discovery. Facts or circumstances or materials are explored for their potential sonic outcomes through activities including composition, performance, improvisation, installation, recording, and listening. These explorations are oriented toward that which is unknown, whether it is remote, complex, opaque, or falsely familiar. (Gottschalk, 2016: 1)

This principle of experimentation with and through music is important to me because it holds at its core the value of inclusivity. An experimental practice brings a non-normative attitude toward music-making, meaning any musical practice can be experimental if its aesthetic or interpretive boundaries are not pre-assigned by the practitioner. Without categorically disallowing any of the received traditions or conventions that accompany canonical artefacts, genres or performance traditions, an experimental practice, for me, foregrounds active *listening* and an ultimate curiosity about how music can potentially be *known*.

It is in this spirit that I have arrived at the documented creative practices which comprise my attached portfolio. While these documents might in some settings be received as my 'interpretations' of musical works, I do not view them as concrete positions that exclude other renderings, and therefore have not subjected them to qualitative means of 'measurement' or assessment. Rather, I view them as 'epistemic objects' (Knorr Cetina, 2001: 181) which have emerged from my embodied research, and which feed back into new practices, provoking yet more questions that drive me to continue researching.

A note on the trajectory of this research

This research began as an investigation into microtonal notation systems and associated interpretive strategies and has arrived at an altogether different focus on epistemologies of practice. Many of my early research questions reflected practical considerations which affected me as a performer of contemporary string quartet music: *What should this score sound like? What is this score asking me to do? How might this composer best notate this sound so I can play it?*

My initial aim, to categorise and frame various practices in terms of commonly associated notation systems, proved ultimately self-defeating, as the practice of pitch would inevitably deviate from any rules I tried to impose. Other questions then began to surface, motivated from within the practice itself: *What is enabling me to 'do' this music? What relationships are being activated in my body when I imagine musical pitch?* These questions became even more essential when asked in the context of teaching technique. Whatever models or descriptions might be present, I found my crucial role as a teacher to be one of mobilising and nurturing a student's embodied knowledge. This trajectory is reflected in the structure of this thesis, which moves from discussions of modelling (Chapter 3) and notating (Chapter 5) pitch to reflections on embodied practices of playing (Chapter 6) and pedagogy (Chapter 7).

The implications of this journey are perhaps helpfully illustrated by an anecdote from my year of teaching Ensemble Performance at the University of Leeds. During the winter of 2017 I created and taught an undergraduate module, designed as an introduction to string tuning practice and microtonal notation. At the outset, my goal for the module was to encourage students to reflect upon the question: *how can understanding microtonal models of pitch space inform and enrich our practice of intonation, and vice versa?*

We began our first session with a group exercise. I asked the students to define two familiar terms: *in tune* and *microtonal*. The definitions could be formal or anecdotal—they had only to express the student's personal understanding of each term. Following a period of personal reflection, each student shared their definitions with the group, and we compiled the following lists of keywords:

IN TUNE

- correct
- right / right notes
- particular
- exact
- desired sounds
- sounds right
- comfortable / satisfying / consistent
- frequency adjusted to official standard
- 440 Hz
- switching from scale to scale
- compromise
- relating to what comes before/after
- overtones (buzz/hum)
- two or more pitches that 'fit' together
- relative

MICROTONAL

- notes/intervals between the 12 tones
- quarter tones
- really small
- smaller than semitones
- smaller than expected
- frequencies between standards
- numbers
- not musically notated
- can't be defined
- adjusted pitches
- hard to hear
- unfamiliar
- relative

The group quickly identified certain common reference points in their collective understanding of these terms. Definitions of *in tune* tended to refer to three main ideas: those relating to *accuracy*, those employing qualitative descriptions of a sonic *ideal*, and those conceptualising pitch as *relative.* Definitions of *microtonal* similarly fell into three main concept areas: those relating to *size* (and more specifically *smallness*), those referring to *unknowability*, and once again, those which discussed pitch as *relative*.

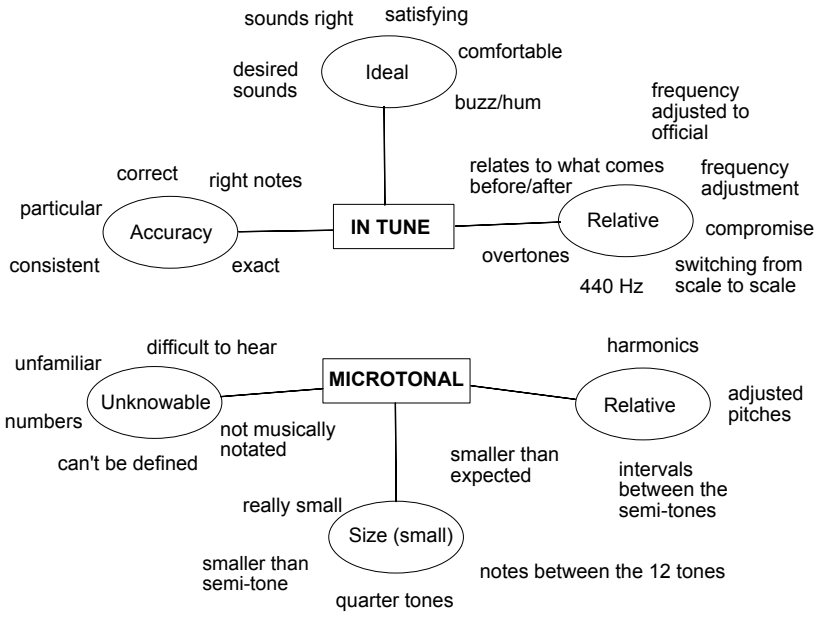

Figure 0.1 *Initial Leeds Concept Map*

While the students clearly understood the two terms to be distinct from one another, they also remarked upon commonalities that appeared to link the two concepts. The harmonic series was jointly referenced, both explicitly (*harmonics, overtones*) and in qualitative terms (*buzz, hum*). Most notably, the capacity for pitch to be heard *relationally* seemed pivotal, and the students agreed that most of their other core concepts were in fact related through this central idea.

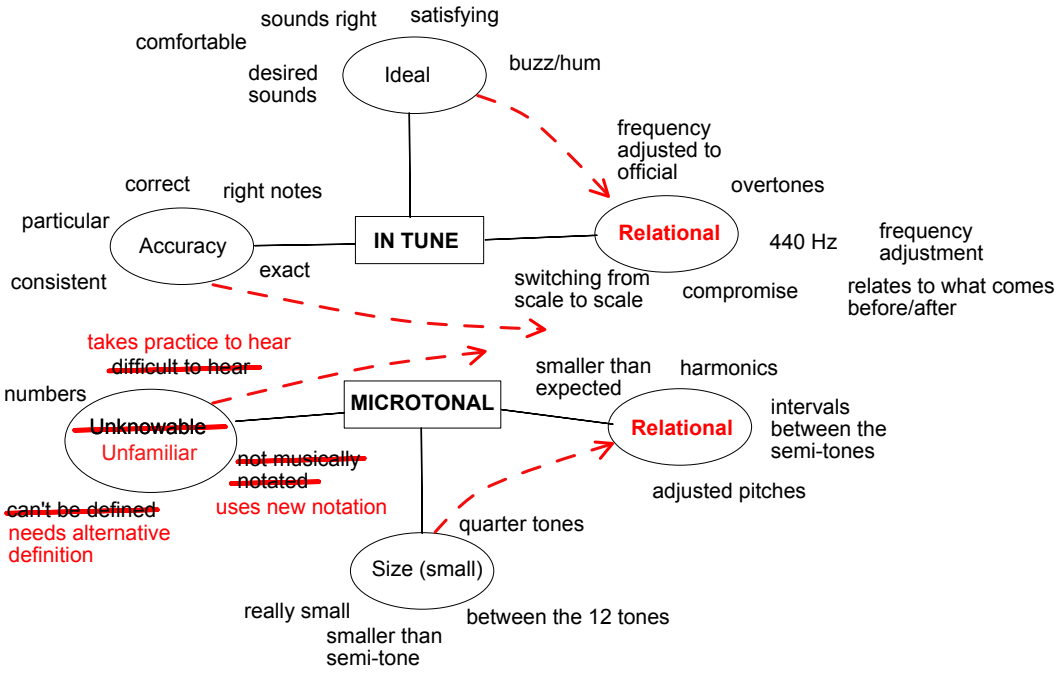

Figure 0.2 *Modified Leeds Concept Map*

In light of these apparent connections the group decided that our initial terms, *in tune* and *microtonal*, might be broadened and re-termed as *intonation* and *microtonality*, and could be best understood as being connected via a central idea: *relationality.* Preliminary links between keywords gave way to concept areas suggestive of interrelated *practices*: Listening, Modelling, Playing.

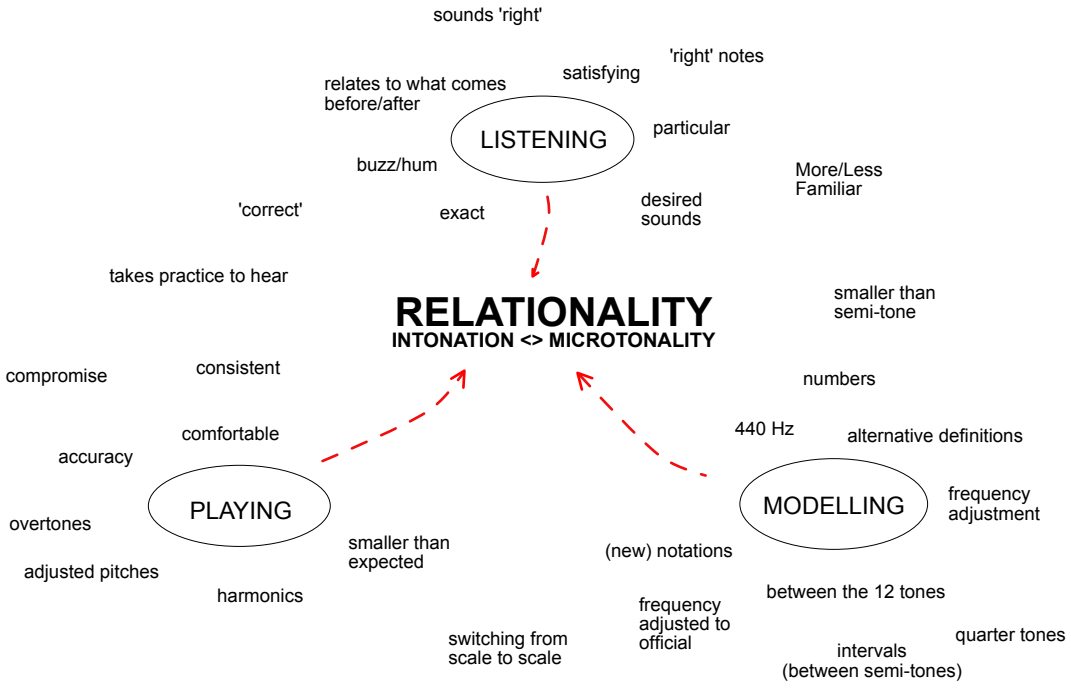

Figure 0.3 *Final Leeds Concept Map: Relationality*

This exercise, and the final concept map that arose from it (Figure 0.3), are illustrative of the practice-led processes that have influenced the trajectory of this research, and my shifting artistic perspective on musical pitch.

Part 1. Five Chameleons

1. Intonation, Microtonality, Technique, Practice

The first two chapters of this thesis explore five multivalent concepts, essential to my creative practice: *microtonality*, *intonation*, *technique*, *practice* and *research.* To begin, I will clarify how these terms will be used, and why.

1.1 Intonation; Technique

Intonation can be generally defined as 'the treatment of musical pitch in performance' (Leedy & Haynes, 2001). Other commonly accepted variations on this definition might include: 'the production of musical tones (by voice or instrument); especially the exactitude of the pitch relations', 'a manner of producing or uttering tones, especially with regard to accuracy of pitch', and 'the ability to play or sing notes in tune' (Barlow, 2014: 1). Some definitions imply value judgements or prescribe outcomes: the Cambridge Dictionary defines intonation as 'the degree to which the notes of a piece of music are played or sung exactly in tune' (Cambridge Online). Meanwhile, the Concise Oxford Dictionary of Music gives 'The act of singing or playing in tune; thus we speak of a singer or instrumentalist's "intonation" as being good or bad' (Kennedy, 1996: 361).

Composer Clarence Barlow notes that definitions such as these

> [shift] the focus to the terms "pitch" and "in tune", of which "pitch" is unproblematic, being associated in a musical context with the physical frequency of a sound, measurable in Hertz. The meaning of "in tune", however, could be a matter of debate. (Barlow, 2014: 1)

Barlow's own rather more impartial definition of intonation accommodates a wider variety of pitch contexts: 'the judicious placement of frequency' (Barlow, 2014: 1).

Common among all these definitions is an expression of agency—the implication that intonation involves both *intention* and *action* on the part of a player. Instrumentalists tend to conceive of this

intention as occurring in the 'mind's ear' (Havas, 1961: 31)—an imagining of sound in a manner akin to the visualisation of image. This process of *audiation* (Gordon, 2018), or *auralisation*[1] as it is sometimes colloquially termed, could be understood as a projection of pitch in the mind (and body) of the player. The performed action which accompanies this intention is cultivated through training and repetition. These components form what will be discussed in this thesis as a *technique of intonation*, which I have described elsewhere in the context of a performance scenario as follows:

> I would observe […] the surrounding context, make decisions based on my observations, audiate my intended sounding result, and carry out a [rehearsed] set of physical and technical movements which would bring me as close as possible to that intention. I would then listen to what had sounded, respond to it, and add that impression to the overall context going forward. (Benjamin and Nickel, 2014: 57)

The degree to which a technique of intonation must be exercised in instrumental performance varies widely between instrument families and is potentially absent altogether. Acoustician and musicologist Patrizio Barbieri classifies instruments according to the nature of the intonation technique necessitated by instrumental construction. Instruments of 'free intonation' (Barbieri, 2008: 107) or flexible pitch—such as the human voice and bowed strings—represent one group; 'enharmonic instruments' (Barbieri, 2008: 39)—such as fretted instruments and some woodwinds—which can employ alternate fingerings to achieve enharmonically equivalent pitches, make up a second group. Barbieri's implied third category, which might be called 'fixed pitch', would include instruments such as the modern piano and the marimba. For instruments of fixed pitch, the establishment of an instrumental intonation is a process that is discrete from the activation of pitches in a musical context: a piano is first tuned and then later played.[2] For enharmonic instruments, intonation requires a careful negotiation between aural skill and the

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[1] This term is sometimes used colloquially among performers (e.g., Bringslid, 2004) and is not to be confused with the acoustical engineering concept, referring to modelling sound in virtual spaces (e.g., Kleiner et al., 1993).

[2] In making this observation, I do not intend to comment on any of the potential influences of the instrumental tuning on other aspects of the player's interpretation—nor on the role of audiation in enabling the player to enact other aspects of their technique, including articulation, timing and tone. The only relevant issue for my current argument is that in the case of fixed-pitch instruments, no decisions are required with regard to intonation in the moment of performance.

constraints imposed by the constructed instrument (i.e., frets or holes). For instruments of flexible pitch, the activation of pitch in a musical context and the intonation of these pitches are achieved through *integrated* action. Every pitch has an intonation, and there are very few pitches which do not require a decision about intonation. This research is concerned with intonation as it is practised on instruments of flexible pitch.

The cognitive and bodily processes through which a string player may develop a technique of intonation are elegantly articulated by theatre practitioner and theorist Ben Spatz, whose *epistemology of embodied practice* (Spatz, 2015: 23) offers a convincing framework in which to begin a discussion about intonation. While Spatz's work is located primarily outside the discipline of musical performance, their contributions to performance scholarship are significant and have profoundly influenced my own research practice. In *What a Body Can Do* (2015) Spatz argues that 'embodied practice is structured by knowledge in the form of technique' (Spatz, 2015: 1). The terms *embodied (embodiment), technique* and *practice* are at the core of Spatz's exegesis, and are adopted frequently in this research. Spatz acknowledges the concept of *embodied knowledge* to include such general descriptions as 'knowledge found within the body' (Spatz, 2015: 1), but further states that

> … "embodiment" absolutely does not refer to a distinction between mind and body […] My assumption here is that mind and body are holistically intertwined—or rather, following current trends in cognitive studies, that mind is an emergent property of body, just as body is the material basis for mind. Thought and language are fully embodied processes. Therefore, when I refer to "embodiment" and "embodied practice" […] I mean to include all of the following: thought, mind, brain, intellect, rationality, speech, and language. (Spatz, 2015: 11)

Neuroscientist and philosopher Francisco Varela, whose theorising of *embodied cognition* has had a fundamental influence on the development of embodied research, reasons

> first, that cognition depends upon the kinds of experience that come from having a body with various sensorimotor capacities, and second, that these individual sensorimotor capacities are themselves embedded in a more encompassing biological, psychological, and cultural context. (Varela et al., 1991: 172–173)

Taking up Valera's argument, Fritjof Capra and Pier Luigi Luisi emphasise that 'the very structure of reason arises from our bodies and brains' (Capra & Luisi, 2014: 272). Where *technique* and *practice* are concerned, Spatz conceives of a relational epistemology in which 'technique is knowledge that structures practice' (Spatz, 2015: 1). They recognise that technique 'structures our actions and practices by offering a range of relatively reliable pathways through any given situation' (Spatz, 2015: 26), but add that 'technique cannot be limited to that which is manual, as it may involve the whole body—not just its physiology but its emotional and mental life as well' (Spatz, 2015: 30).

An instrumentalist faced with a challenging performance scenario is likely to identify strongly with these statements, recognising the extent to which technique offers both the 'reliable pathways' of reflex and rehearsed gesture, and also a *way of knowing* that is distinct from other forms of knowledge relevant to the discipline, such as the symbolic representations contained within a musical score. Spatz proposes that a re-theorization of technique (2015: 27) is necessary if technique is to be understood not as 'merely mechanical' (2015: 29), but as something *epistemic*—'structured by and productive of knowledge' (2015: 26).

Practices, in the context of this re-theorised technique, are 'concrete examples of actions, moments of doing, historical instances of materialized activity' (Spatz, 2015: 41). Spatz argues that this relational view of technique and practice

> allows us to distinguish between a given *practice* […] bounded in time and space [and a *technique*] which is not merely a repeated pattern or set of rules but an area of practical and technical knowledge. (Spatz, 2015: 40)

Clearly, the cognitive and bodily processes that enable a player to approach frequency with judiciousness are generously accommodated by Spatz's model. Following this thinking, a player's *technique of intonation*—a growable, 'transmissible' area of knowledge, held in the body (Spatz, 2015: 9)—structures their *practice of intonation*—any and all of the unique instantiations of that technique, as applied in a performance situation, in the practice studio, or in any other occurrence where the technique is put to use. This epistemology of practice stands in contrast with much of the discourse surrounding string performance and pedagogy, yet it furnishes an ideal framework in which to discuss the technique and/or practice of string intonation, for several reasons.

First, conventional string discourse has tended to regard technique as a distinctly physical, and more specifically *manual* discipline. Whilst instrumental treatises and pedagogical texts regularly address the development of strength, agility and accuracy in the hands and fingers[3], the less observable but, by Spatz's terms, equally embodied techniques of listening, perceiving and reflecting on sound tend to be acknowledged only in passing, and seem in many texts to be taken for granted. Violist Michael Kimber observes that while students are frequently urged to 'listen intently', teachers seldom dwell on *what* they should listen to, and *how* this listening can be effective (Kimber, 1992: 59).

Where string discourse *has* historically engaged with perceptual or cognitive aspects of technique, it has often been to encourage a *dissociation* between notions of 'cognition' and 'artistry'. Influential violinist and pedagogue Carl Flesch epitomised this tendency with the statement:

> It is the amalgamation of tone and of abstract ideas which always inspires the practical musician, filled with living sound, with a ghastly fear of theoretical treatises. (Flesch, 1930a: 1)

Celebrated violin pedagogue Ivan Galamian reflects a similar, if less reactionary, sentiment, writing, 'no violinist can play according to a mathematical formula; he can only follow the judgement of his own ear' (Galamian, 1962/85: 22). These statements in no way negate the capacity of embodied knowledge, yet they do seem to limit the scope of that knowledge to Spatz's rudimentary notion of 'knowledge held within the body' whilst, to echo Kimber's criticisms, neglecting to consider fully how that knowledge may be registered and activated within the 'holistically intertwined' organism.

Second, as will be discussed in Chapter 4 of this thesis, even where discussion is confined to the manual areas of technique, intonation has remained an area of non-consensus among string practitioners. A general fuzziness pervades the topic: standards are referenced without first being established, statements of opinion are offered as unqualified criticism, and borrowing and adaptation of terminology causes confusion between texts of different authors. As violinist Goetz

[3] As discussed at length in Chapter 4.

Richter reflects:

> Intonation seems to be an area which under certain circumstances we perceive is best left alone. We don't venture into a discussion of intonation in specific terms. There seems in any case at times little agreement about intonation—little agreement in perception or practice. […] After all, so the argument goes, there are plenty of excellent violinists that have not thought about this issue and play beautifully in tune. Do not wake the somnambulist while sleepwalking! (Richter, 2006: 1)

Spatz's model re-orientates a discourse that is heavy with the received biases of string performance culture, providing a framework through which players' discussions of intonation technique can be reflected upon critically, and contribute to wider research on embodied knowledge.

Third, as will be discussed in Chapter 2, Spatz's epistemology of practice has profound implications for the evolving discourse on *practice research*, and particularly how performance contributes to that discourse. To accept Spatz's statement that 'knowledge inheres in practice' (Spatz, 2015: 25), and to understand technique as embodied knowledge, leads to the justifiable argument that the development of technique may be viewed as the production of new knowledge, and thus practice constitutes research.

Of immediate pertinence to the present discussion is the assumption that intonation technique is located primarily in the hands, and that the ears serve exclusively (or primarily) as references for this manual technique. Intonation technique is frequently characterised as a two-step process of audiation followed by actualisation (Fig. 1.1.1), as exemplified by Galamian's statement:

> Eventually […] the mere act of mentally preparing the movement and thinking the sound of the desired pitch will be sufficient to cause the fingers automatically to hit the right places on the strings. (Galamian, 1962/85: 20)

Galamian's appraisal, while it may broadly reflect some instances of practice, gives a severely reduced account of what can transpire in a technique of intonation. His notable devaluation of 'mere' acts of 'mentally preparing' and 'thinking' suggests that he does not consider these to be 'technique', which seems to encompass only the movements of the fingers. Moreover,

Galamian's view does not account for a transition between the two components. Action, it is suggested, results from intention. How, and through what means, appears not to be a matter of concern.

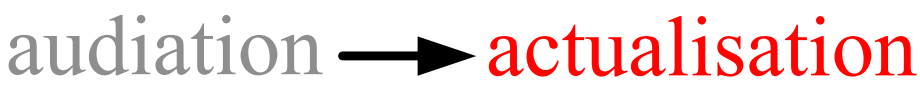

Figure 1.1.1 *Audiation leads to actualisation*

In light of Spatz's writings, a technique of intonation might be better characterised as an epistemic cycle in which elements of *action, observation*, and *reflection* are afforded equal recognition within the technique. To quote Varela, 'in reflection we find ourselves in a circle: we are in a world that seems to be there before reflection begins, but that world is not separate from us' (Varela et al., 1991: 3).

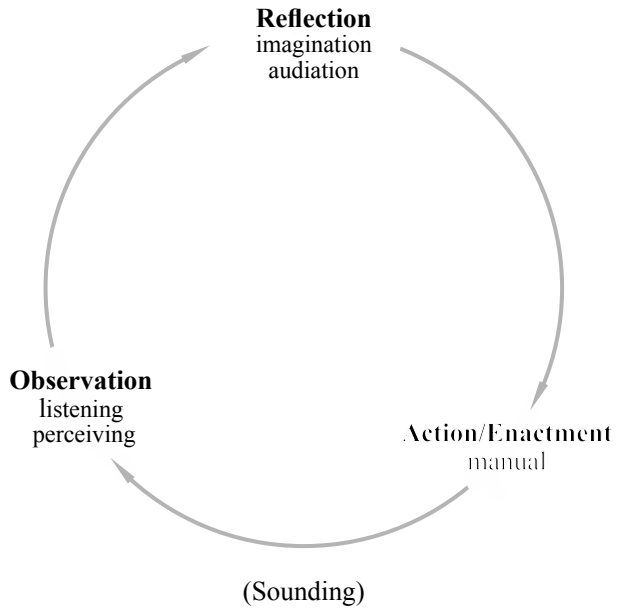

Figure 1.1.2 *A cycle of embodied technique*

An example of a player's various *practices* of intonation might, then, be represented in this way, reflecting my own experience:

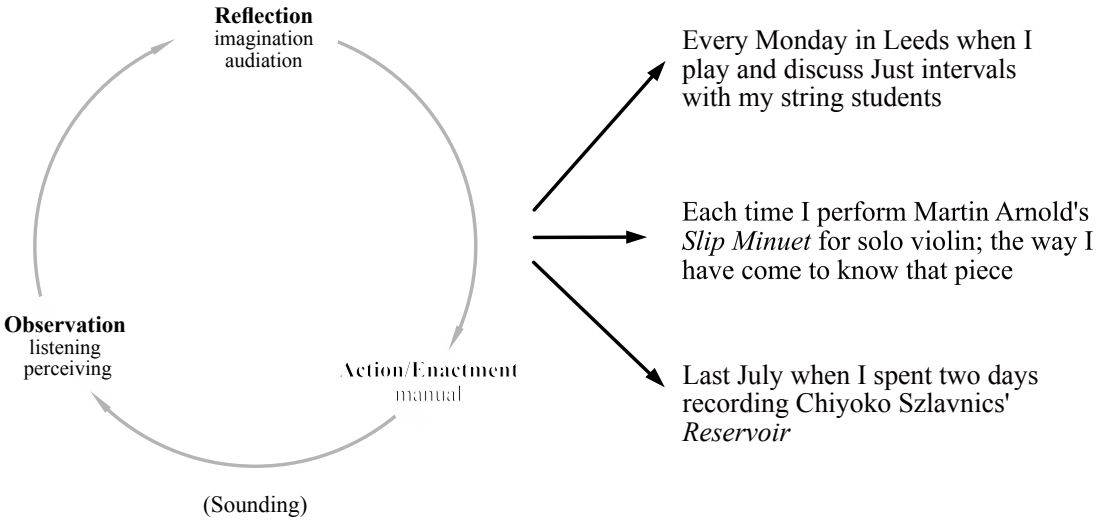

Figure 1.1.3 *Practice as the instantiation of technique*

These representations depict an uninterrupted cycle of observation, reflection and action, in which the body retains complete agency in the unfolding of sound. An entirely accurate representation of a technique of string intonation, however, must take into account that there is a component, namely the instrument, which is not embodied.

Below (Figure 1.1.4), two areas of embodied technique—one manual and one perceptual—are shown to be connected by way of an unembodied element. On the right-hand side of this representation, technique held in the physiology of the hands and wider body is enacted upon the instrument. On the left-hand side of this representation, technique held in the physiology of the inner ear[4], and in the perceptual and rational centres of the brain, is enacted. Connecting these two hemispheres is a material body—in my own case, a violin. The enactment of embodied technique

[4] James Tenney provides a succinct yet relevant summary of the physiology of pitch perception in his essay 'The Several dimensions of Pitch Space'; See: Tenney et al. (2015), 369–381.

upon what Spatz might call 'technology in the sense of a manufactured object' (Spatz, 2015: 32) produces sound which is neither fully embodied nor fully technological. The intervention of the technology into the embodied technique is in many ways definitive of the technique, as it establishes a point of material agency[5] in what might otherwise unfold as a continuous experience of embodiment.[6]

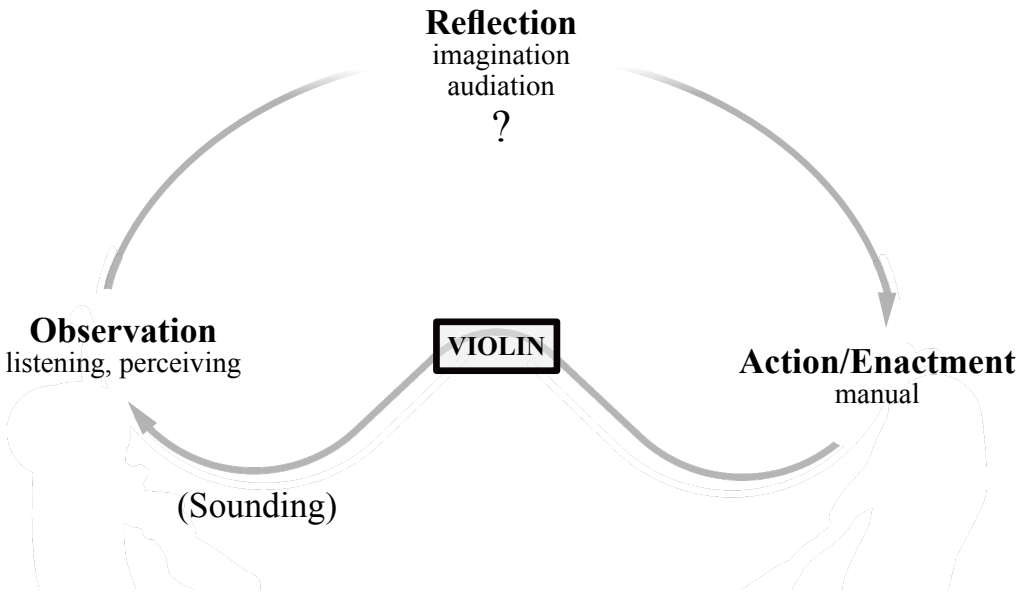

Figure 1.1.4 *A cycle of embodied technique in the practice of an instrument*

Much study has been made of the right-hand lobe of this representation, being the primary objective of string performance treatises going back centuries (of which a representative cross section will be examined in Chapter 4). Equally, exploration of the physics and ontologies of the left-hand lobe has been the object of research in music cognition and psychoacoustics—although more extensive discussion of how this research contributes to string technique is certainly warranted.

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[5] The material agency of the violin will be further discussed in Chapter 6.6 in connection with the work of Scott Mc Laughlin.
[6] The *Deep Listening* practices of composer Pauline Oliveros, discussed further in Chapter 4, might constitute one such experience.

At the top of this representation occurs what I have called ‘reflection’. This is a defining component in a technique of intonation, and yet few players and/or performance scholars seem eager to transgress its fuzzy margins. Galamian’s aforementioned assessment would seem to imply that this moment is not in itself technique, but rather some manner of abrupt *flip* upon which thinking becomes doing. A critically reflective player might instead recognise a distinct element of technique—a taking-on of observation by the body, and a moment of pre-action, or an embodied projection of potential action. Perhaps this view aligns more easily with the tried-and-tested practice-room adage of the *mind’s ear*—the excitement of the imagination in the moment of audiation.

This moment of embodied reflection deserves further interrogation, at least where string intonation is concerned. If technique, as Spatz asserts, ‘involves a detailed and context-dependent negotiation between socially defined or symbolic meaning and the concrete possibilities offered by the material world’ (Spatz, 2015: 31), then string players must scrutinise not only the manual component of their technique, but the entire field of their embodied knowledge.

It is the suggestion of this research that such socially defined and symbolic meanings, representative of our culturally engendered references, reside in the reflective moment and supply our cognitive representations in the enactment of technique. In order to undertake this line of enquiry, more precise meaning must be sought in another term: *microtonality*.

1.2 Microtonality; Practice

The terms *microtone* and *microtonal* appeared in English music theory texts beginning in the early 20th century, with early significant use in 1912 by violinist and Indian music theorist Maud MacCarthy Mann in her discussion of *srutis* of Indian music (MacCarthy Mann, 1912). Standard definitions of these (and related) terms tend to describe intervals ‘smaller than a semitone’ (Randel, 1986: 491)—the colloquial *quarter tone* being an obvious and frequently relied-upon example. Further and supplemental definitions cite the use of intervals *other* than the semitone, pointing variously to non-European musics, as well as scales and pitch collections arrived at through historic or novel tuning systems.

Theorist Margo Schulter recognises the importance of context in defining the roles and identities of musical pitches, and defines microtonality as

> the use of any interval or tuning system deemed unusual or different in a given cultural setting—in many 20th–21st century settings, for example, just about any tuning for keyboard or guitar other than a division of the octave into 12 equal semitones….[7] (Schulter, no date)

Schulter's definition retains an idea persistent in the discussion of microtonality: the *semitone* and deviation from it. The ubiquity of this reference solicits fundamental questions, principal among them being *what kind of 'semitone'?* The 12-tone Equal Division of the Octave (12-EDO) described by Schulter is undoubtedly the semitone most commonly imagined by contemporary readers of Western classical music. However, the normative status attributed to this 12-EDO semitone inaccurately reflects the nuanced intonation practice of most string players.

Violinist Mieko Kanno reflects on the effect of the standardisation of 12-EDO upon string performance and composition:

> The global dissemination of equal temperament around the turn of the eighteenth century had little effect on the playability of the instruments of the violin family. The four strings of the violin remained unchanged, having the intervals of a perfect fifth in between them. But the effect on performance practice was considerable: gone was the ritual of tuning and playing instruments to different temperaments depending on the musical and practical constraints. […] Pitch became an abstract commodity while intonation became a practical topic. The vital link between composition and performance was broken. Intonation became an issue of performance practice alone. (Kanno, 2003: 36)

While the role of tuning practice in the development of Western classical music has been much discussed from various musicological perspectives (e.g., Stowell, 1985; Barbieri & Mangsen, 1991; Duffin, 2007;), Kanno's argument clarifies the extent to which the segregation of pitch and intonation has caused a paradigmatic shift in how practices of both performance and composition

[7] The interval described above by Schulter is arrived at through dividing an octave (assumed as a 2:1 frequency ratio) into 12 equal parts; the resulting interval can then be expressed as $12\sqrt{2}$.

are positioned. What was an essential part of musical practice has become at best a specialist field, at worst an obsolete remnant; the judicious placement of frequency has become an 'extended technique'.

In recent decades, the designation of *microtonal composer* has been given to individuals working in musical genres as diverse as electronic, rock and avant-garde. The thread connecting these otherwise diverse practices has been the perceived use of altered or extended tonalities, or of pitch material perceived to be outside of, or extended from, normative pitch material. The musicologist Bob Gilmore, a defining contributor to contemporary scholarship and performance of what is often called 'microtonal music', questions this 'odd usage', and remarks:

> Microtones are to the pitch domain roughly what "extended techniques" are to the timbral domain. ("Extended techniques" was a term that gained vogue in the 1960s to describe the use of fluttertonguing, multiphonics, etc., on wind instruments, or various kinds of sul ponticello or sul tasto on strings.) Nowadays "extended techniques" are an integral part of a new music player's vocabulary, just like microtones. But you'd never think of describing Berio, say, as an "extended techniques composer", and it seems to me it makes equally little sense to describe someone as a "microtonal composer". (Gilmore, 2005: 1)

Gilmore's argument is only strengthened by the inclusion of instrumentalists in his analogy: it would be a misnomer to call a violinist a 'microtonal performer', understanding in light of Spatz's writings that the realisation of any given musical material is representative only of one instance of practice by that player, and not of the whole potential of their technique of intonation, let alone any other embodied techniques or practices with which they engage.

Furthermore, as Kanno (2003: 36) points out, the practice of tuning string instruments *relationally*, in perfect fifths, establishes simple, consonant[8] frequency relationships as the enduring basis of string intonation. For many players, the prospect of replacing these consonant intervals with comparatively dissonant 12-EDO intervals would go against the fundaments of 'good' intonation practice. As such, a string player's technique of intonation is less reliant on

[8] The relationship between acoustic complexity and perceived consonance will be further discussed in Chapter 3.

'default' pitches and more reliant on relational hearing. Pitches are tuned to other pitches, which may *have* sounded, may *be* sounding, may be *about* to sound, or may *potentially* sound. Considering the above basic definitions of microtonality, a violinist might justifiably ask which pitches are the 'normal' ones, and which are therefore 'extended'?

The challenge is easily illustrated by considering how a string player might approach a common interval, such as this major sixth:

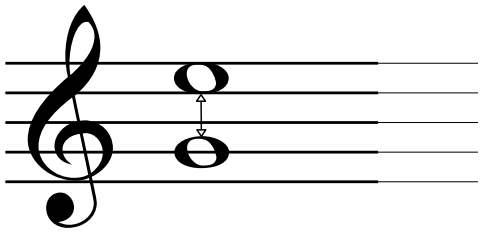

Figure 1.2.1 *Major sixth*

A violinist is likely to conceive of this interval as a relationship, rather than as two unrelated pitches, and can hone this relationship by adjusting the intonation of either or both pitches. This decision may be informed by contextual factors, such as perceived harmonic or melodic function, by the intonation of accompanying instruments, and to varying degrees, by interpretive discretion. Once established, any proportional relationship can be retained (Figure 1.2.2) while being placed at different *pitch heights* (Tenney et al., 2015: 295). Again, this decision may be influenced by various contextual or interpretive factors.

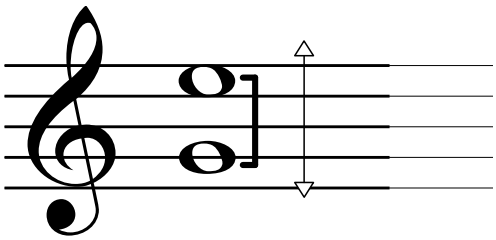

Figure 1.2.2 *A Major sixth at variable pitch heights*

Evidently, definitions of microtonality that rely on the principle of deviation from 12-EDO are not broad enough to accommodate a nuanced practice of string intonation. By these terms,

virtually all music performed on a string instrument might be called ‘microtonal’. Consistencies now become apparent between what have so far been called ‘intonation’ and ‘microtonality’. The violinist and composer Marc Sabat has pertinently described pitch as occupying a ‘glissando-continuum’ and offers his own definitions of intonation and microtonality which effectively bypass notions of normative pitch altogether:

> I would describe *intonation* as the art of selecting pitches, or (more accurately) pitch-“regions” along the glissando-continuum of pitch-height [...]. The “tolerance” or exactitude of such regions varies based on the instrument and musical style. In this context, *microtonality* is an approach to pitch which acknowledges the musical possibility of this entire glissando-continuum and is not limited to the conventional twelve equal tempered pitch-classes. (Sabat, 2005)

Sabat’s microtonality is distinctive, first, in that it *includes* the 12-EDO within the glissando-continuum—in effect de-prioritising that rigid model and replacing it with a more open, malleable surface; and second, in that it is rooted in his own technique of intonation. The *approach* of pitch is here foregrounded, as the player is invited to inhabit a negotiable pitch *space*. The player reaches out into this space to *seek* pitch, coming to know locations as proximities, whilst noticing only incidentally the gridlines that might once have seemed essential.

To imagine microtonality as a spatial practice is by no means a novel metaphor. ‘Pitch space’ has been a recurrent premise among theorists, as seen in the harmonic lattice models of James Tenney (2015) and Harry Partch (1974), as well as in functional harmonic models such as those of Fred Lerdahl (2001) and Dmitri Tymoczko (2010). It is Sabat’s focus on continuity—on the possibility of a whole, uninterrupted continuum of pitch space—which transforms what is otherwise a semantic device into an arena for embodied practice.

Capra and Luisi (2014: 272) might see this spatial metaphor as further evidence of the ‘mind’s embodiment’, while George Lakoff and Mark Johnson suggest that ‘our bodies define a set of fundamental spatial relations that we use not only in orienting ourselves, but in perceiving the relationship of one object to another’ (quoted in Capra & Luisi, 2014: 272). Meanwhile, Sabat reflects:

> … [with] a concept like pitch space, you can envision it on paper, like a cartography—like a map of the whole planet—and [this gives] an overview, which would be like looking at something from above. With the sounding of tonal constellations, one is always sort of local, and you have a very detailed local perspective. The *fine-tuning* of [a harmony] of course projects more precisely to distant points in the space. […] To achieve this, you have to inhabit space… see what it's like to move through the space. (M. Sabat, personal correspondence, 6 May 2017[9])

If string players are to imagine pitch as a negotiable space in which fixed references are superseded by proximities, then we find ourselves in want of tools with which to model these relationships. To acknowledge the benefit of such tools is not to reduce a dynamic practice once again to a collection of fixed models. Rather, in modelling, and sharing models between us, we may orientate ourselves and move through pitch space with greater confidence and purpose. Gilmore explains:

> Most models are designed not merely to provide a description of a pitch "space" but to suggest or embody an explanation of it. All such models are attempts to circumscribe and make manifest the processes by which we form cognitive representations of musical materials. Clearly, the model and the observations that arise from it are linked: observation is done in the ambience of the model; the model is created in the context of an observation strategy. This interaction helps evolve the adequacy of the model and the sensitivity of the observation. (Gilmore, 1995: 458)

Perhaps Gilmore may lend some clarification to the ambiguous 'reflection' component previously identified in my representations of intonation technique. If reflection occurs between observation and action, then it must relate both forward and backward in the cycle of technique, contextualising what has been observed and informing what might next be done. Clearly there is an element of decision-making in a player's process of reflection, but in contrast to Galamian's suggestion that this decision is a linear act of *thinking-then-doing*, Gilmore and Spatz might agree that some negotiation takes place between the awareness of the body and those 'socially defined

[9] All comments cited from Sabat (2017) are taken from an interview conducted 6 May 2017 in London, UK.

and symbolic meanings' that Spatz acknowledges are present in a player's evolving practice (Fig. 1.2.3).

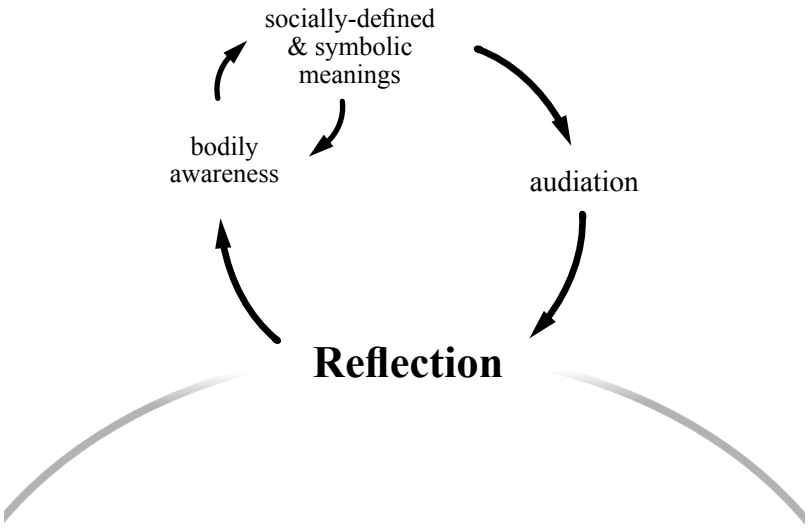

Figure 1.2.3 *The reflective component of intonation technique*

For example, when imagining an interval, a player might recall a frequency ratio which they associate with certain acoustic characteristics; they may imagine the location of each discrete pitch as it deviates from a more familiar reference pitch; they may imagine the interval as having a certain 'sweetness' or 'brightness'; they may imagine the interval proprioceptively by mapping locations on the physical instrument. These divergent modalities bring distinct preferences and imply different epistemologies of musical pitch, and in reflective integration with bodily awareness will influence the nature and result of the player's audiation.

Varela suggests that 'we find ourselves performing [acts] of reflection out of a given background…of biological, social, and cultural beliefs and practises' (Varela et al., 1991: 11). In the context of a practice of intonation, these influences might take the form of an established model of pitch space, or of a particular qualitative description which carries meaning for the player. In some cases, models may be closely associated with particular systems of notation, which Sabat believes can 'open a space' in the player's mind:

> The reason that I write certain things down is that then I can really get into their sounding, by having distinguished them. For example, you can experience a very small comma interval through the way the sounds interact. If you actually write that down […] you open up a space between, say, [two versions of] E, which then can't be closed. It adds a whole range of sounding phenomena, all of which are in your mind when you see E. (Sabat, 2017)

Clearly, cognitive representations of pitch space, and the notations which might be employed to signify them, are distinct things. Yet, in what has by now been established as a field of practice of microtonality, these symbolic representations may be brought frequently into an active, reflective dynamic with the player's embodied technique. Therefore, in the context of this research, microtonality may be understood as the various embodied (and semantic) practices through which pitch space can be modelled in the playing of a string instrument. A string player's *embodied practices* of microtonality are structured by their *technique* of intonation.

Given the apparent circularity of these discussions, which arrive as they began with techniques of intonation, one might find oneself musing, as Bob Gilmore once did,

> Do we still need the word [microtonality] or is it already past its expiry date? […] My view is that the closer we look toward the future the more we realise that a History of Microtonality will quickly become —I'd even say already is—simply one part of a History of Music, and that all the most interesting microtonal music is, at the end of the day, simply music. (Gilmore, 2005: 4)

For string players, whose aspirations toward the judicious placement of frequency are likely to guide them toward similar embodied conclusions, a poignant next question might be, how might our practices of microtonality inform and enrich our techniques of intonation?

2. Practice Research

Chapter 1 outlined how a player's technique of intonation may be understood to structure embodied practices of intonation and microtonality, following the *epistemology of practice* set out by Ben Spatz (2015). While Spatz's theory provides a compelling argument for the positioning of many diverse artistic practices as *embodied research*, their particular definition of practice is temporarily set aside in this section, in order to broaden the context surrounding my own practice research.

This chapter contextualises my research within current and evolving discourses on Artistic Practice as Research, with specific reference to Performance Studies, in order to establish a statement of position at the intersection of some relevant discussions. The *Instances of Practice* presented in Chapters 6 and 7 are then demonstrated to be representative of original research in light of Spatz's assertion: 'if technique is knowledge, then practice can be research' (Spatz, 2015: 61).

Artistic (Practice as) Research

'If the urgency of an issue can be measured by the ferocity of the debates surrounding it,' writes Henk Borgdorff, 'then the issue of "research in the arts" is an urgent one' (Borgdorff, 2012: 31). At the centre of the lively debate surrounding Artistic (Practice as) Research, which has gained momentum in recent decades not least in UK academia[1], have been the reciprocal questions: '*when does art practice count as research?* and *when is research artistic?* Borgdorff writes:

> Under labels such as 'art practice as research' or 'research in and through the arts', a discussion topic has arisen in recent years that has elements both of philosophy (notably epistemology and methodology) and of educational politics and strategies. That makes it

[1] As evidenced by the establishment of institutions, networks and study groups with a focus on Practice as Research, including the Performance Studies Network, Centre for Music Performance Research (RNCM), CHARM (AHRC), and the Orpheus Institute.

> a hybrid issue, and that does not always promote the clarity of the debate. (Borgdorff, 2012: 31)

This very plurality of Practice Research has become an identity. Michael Schwab proposes that 'not knowing what exactly Artistic Research is … is a good thing' (Schwab, 2017), while Anthony Gritten argues that 'clarity might not be the best—artistically most productive—way of apprehending and making artistic use of the relationship between practice and research' (Gritten in Dack, 2015: 79). Reflecting on divergent theories in the closely-related field of *performativity*, James Loxley concludes that this discourse 'has not added up to a single, easily assimilable idea' and that 'invoking it brings us not the safety of an answer, but the ongoing pressure of a question' (Andersen, 2016: 12). As well as increasing 'the stock of knowledge', Julian Klein proposes that artistic research connotes 'the state of not knowing—or even better, not yet knowing along with a desire for knowledge' (Klein, 2017).

A now well-established tripartite delineation of Artistic Research, based on an idea introduced by Christopher Frayling in 1993 and here articulated by Borgdorff, defines three potential dynamics: 'research on the arts', 'research for the arts', and 'research in the arts' (Borgdorff, 2012: 6). Research *on* the arts takes art as its 'object' and implies a 'theoretical distance' between the researcher and the 'research object' (Borgdorff, 2012: 6). Research *on* intonation might take the form of a comparative study of spectrographic analyses of various intonation practices in a specific work (see Johnson in Davidson, 2004: 79–90), viewed as evidence of performance practice.

Research *for* the arts is 'applied research' which makes art its 'objective' and delivers 'the tools and the knowledge of materials that are needed during the creative process' (Borgdorff, 2012: 6). Research *for* intonation might include the study of a particular approach to pitch space, taking into consideration both symbolic and embodied components of practice (see Sabat, 2006).

Finally, research *in* the arts 'does not assume the separation of subject and object' (Borgdorff, 2012: 7). Research *in* intonation would therefore occur in the *practicing* of intonation. In Borgdorff's words, such a research approach

> does not observe a distance between the researcher and the practice of art. Instead, the artistic practice itself is an essential component of both the research process and the research results. This approach is based on the understanding that no fundamental separation exists between theory and practice in the arts. […] Concepts and theories,

> experiences and understandings are interwoven with art practices and, partly for this reason, art is always reflexive. Research in the arts hence seeks to articulate some of this embodied knowledge throughout the creative process and in the art object. (Borgdorff, 2012: 7)

Spatz's epistemology of practice is aligned most closely with this final branch of the tripartite. Spatz proposes that 'embodied technique could be conceived as a major branch or division of human knowledge, alongside the sciences and the humanities', and that 'an epistemic impulse—rather than a commercial or otherwise instrumental one—can be at the heart of the most deeply embodied practices' (Spatz, 2015: 218).

In each of Borgdorff's dynamics a different relationship is implied between 'practice' and 'research', which to varying extents remain distinct components. However, as Schwab articulates, the overarching principle is that 'artistic research … is not just another word for "practice"' (Schwab, 2017). To validate the capacity of artistic research to 'elude strict classifications and demarcations' (Borgdorff, 2012: 7) is not necessarily to argue that 'epistemologically less might be artistically more' (Gritten, 2015: 89). On the contrary, Schwab suggests, 'to establish artistic practice as research, an artistic epistemology is required' (Schwab, 2015: 130).

'Performer's Analysis'

Efforts to determine the identities and relationship of practice and research have arrived later[2] in music than in other fields of art practice, such as visual art and design, and in music performance have been largely concentrated in the area of Performance Studies. Players and performance scholars have long recognised the necessity, in John Rink's words, 'that performers themselves come to assume greater priority within the [Performance Studies] discipline' (Rink in Davidson, 2004: 41), but have encountered difficulties in reconciling their own embodied practices with the impositions of text—primarily in the form of musical scores—as the medium through which players must often interact with other disciplines of research in music, including composition and analysis. Players of notated music are inevitably drawn into the larger dialectic of the score-as-

[2] For example, Borgroff writes: 'Some discussion does seem to be stirring in the field of music in recent years. In 2004, a European network was set up consisting of music institutes with doctoral arts studies (MIDAS), and the AEC (European Association of Conservatoires) has also recently launched a working group to consider the doctoral (third) cycle.' (Borgdorff, 2012: 4)

work, which Lydia Goehr has shown emerged only in the late 18th century 'alongside the emergence of music as an autonomous fine art' (Goehr, 1992: 113).[3]

The negotiation of scores and notation supplies many tributaries of discussion within Performance Studies, and will be discussed in detail relative to my own practice in Chapters 5 and 6. However, concerning the *pitch* parameter of notation, with which this research is primarily concerned, very broad points of consensus suggest themselves in questions of *signification* (which will be explored in Chapter 5) and of *agency.* In this latter gathering point, disagreement often centres around perceived differences and suggested hierarchies between performative vs theoretical readings of scores, the latter of which Nicholas Cook suggests has been music's long-standing contribution to mainstream research in a broad scholarly sense (Cook, 2013).

It is likely for this reason that some significant discussions in Performance Studies over the past two decades have taken the form of 'face-offs' between those identified as 'performers' and those identified as 'theorists'. Inflammatory statements from theorists, suggesting that 'players should understand what they play' (Lester in Rink, 1995: 197), have incited impassioned rebuttals from performers, who argue that 'cognitive studies of performance reveal little or nothing about the specificities of interesting and exceptional performance' (Clarke in Rink, 1995: 52). Theorist Wallace Berry is frequently cited as an antagonist in essays on performance scholarship, having argued in his book on *Musical Form and Performance* (1985) that

> the purely spontaneous, unknowing and unquestioned impulse is not enough to inspire convincing performance. […] [Although] the interpreter's impulsive response to the score can fortuitously hit on convincing approaches through a developed (if often unreasoned) sense of appropriateness, the purely intuitive is unlikely to afford a necessary grasp of—or place in—the comprehended whole. (Berry, cited by Lester in Rink, 1995: 197)

Rink conversely questions the validity of 'doctrinaire school[s] of thought virtually requiring performers to base their interpretations on the findings of rigorous analysis' (Rink, 2002: 36), and asserts:

> performers are continually engaged in a process of "analysis", only of a kind different from that employed in published analyses. This sort of "analysis" is not some

[3] Notably, by Goehr's suggestion, the work concept emerged substantially *after* the development of modern string technique.

> independent procedure applied to the act of interpretation but rather an integral part of the performing process. (Rink, 2002: 36)

Differentiating what he calls 'performer's analysis' from 'published analysis', Rink describes 'the importance of musical "shape", rather than structure, in the performer's conceptualisation of music—an elusive but elucidatory notion more temporally conceived than that of structure' (Rink, 2002: 36). Rink's portrayal of this immersive vs representational analysis is echoed in Nicholas Cook's suggestion that performance is 'an art of transitioning […] oriented to precisely the horizontal dimension of music that the spatialised, hierarchical models of theorist's analysis de-emphasise' (Cook, 2013: 46). Cook draws too on the writings of Mark Johnson and Steve Larson, as they distinguish 'the perspective of the observer, who as it were lies above the landscape and can see the whole at once', from 'the pedestrian perspective of the participant [who experiences] the music as a continuous unfolding from one moment to the next' (Cook, 2013: 45).

Setting aside for the moment any narrative connotations that stand to limit the scope of practice represented by these descriptions, the dispute above represented by Rink and Berry is essentially a difference in *ways of knowing*. Berry's argument is rooted in what Thomas DeLio calls a 'traditional notion of form as a closed framework' in which

> "content" represents a type of metaphysical reflection upon the nature of things in which the self emerges as a static entity possessing knowledge of, but always remaining separate from, all other things of the world. (DeLio, 1984: 2)

Rink's argument, although perhaps biased in its stylistic allegiances, is essentially advocating what DeLio calls a more 'open manifestation' in which

> content becomes substantially the same as process as it is engulfed by that perpetual state of imminence which is the essence of each individual's experience of being in the world (DeLio, 1984: 3).

Thus, whatever tension might be observed or imagined between theory (as represented by Berry) and practice (as represented by Rink) might be characterised as a difference in ontological priority—in DeLio's words, the former '[treating] form as an entity ontologically prior to process', while the latter 'treats process as ontologically prior to form' (DeLio, 1984: 3). Spatz observes an unfortunate interdisciplinary bias toward the former, writing:

> Implicit in the tension between theory and practice is the idea that "practice" is not epistemic in nature. It is assumed, in other words, that "knowing" is a matter of "thinking" rather than "doing." (Spatz, 2015: 223)

Cook (2013: 41) remarks that this preconception might be attributed to 'the persistent influence of Cartesian dualism' which easily becomes 'a means of disciplining the performing body, subjecting it to a mentalistic construal of the musical work'. Varela, meanwhile, delivers a more pointed criticism of the Cartesian position, calling it 'a product of specific practises—those of disembodied, un-mindful reflection' (Varela et al*.,* 1991: 28).

Hoping to open a space for different dynamics of interaction between 'performance' and 'analysis', Cook introduces his own triptych: 'Theorists's Analysis', 'Performer's Analysis' and 'Performance Analysis' (Cook, 2013: 33–55). Although no explicit correlation is stated, these branches of performance analysis bare some resemblance to the dynamics implied in the Borgdorff/Frayling practice research tripartite.

Performance Analysis views playing as 'an object of analysis' (Cook, 2013: 49) and thus mirrors some of the approaches taken in Borgdorff's 'research on the arts'. A performance analysis with a focus on intonation might take the form of a comparative study of the tuning practices of several string quartets performing the same work, considering testimonials, rehearsal notes and/or audio documentation (e.g., Johnson in Davidson, 2004: 79).

Performer's Analysis is '[analysis] by performers that directly address[es] performance concerns' (Cook, 2013: 43), and thus shares some objectives with 'research for the arts'. Rink proposes a method by which the performer might 'discover the music's "shape", as opposed to structure' (Rink in Cook, 2013: 48), by means of visually graphing a registral 'skeleton' of pitch height that he argues 'approximates the moment-by-moment narrative of the performance while also synchronically illustrating its profile and topography' (Rink in Davidson, 2004: 47). Similar graphs of intonation practices in Beethoven string quartets have been undertaken by Peter Johnson (see Johnson in Davidson, 2004: 82).

Theorist's Analysis is seen by Cook to imply the highest degree of prescription upon players, in that it 'assumes that meaning is concentrated in coherent wholes rather than the transitions between them' (Cook, 2013: 46). For this reason, Cook (2013: 46) comments that such a manner of analysis 'often seems irrelevant in performance'. A theorist's analysis is thus presented as the most epistemologically distant from Borgdorff's remaining 'research in the arts' dynamic. Yet,

ironically, it also comes nearest to fulfilling the dynamic of 'practice *as* research' in that it reflects both the methods and outcomes of practice—only that of theorists, and not players.[4] That these practices are received as prescriptions (even oppressions) by players speaks volumes about the privileges and preconceptions held by practitioners in both fields, as Cook reflects:

> The fact that […] the relationship between analysis and performance is [still] being negotiated on the printed page is a metonym of the more general situation of performance within the discourses and institutions of academia: as long as the mechanisms of research accreditation and career advancement remain wedded to the written word, interactions between analysts and performers will be always fixtures for the latter. (Cook, 2013: 40)

The drive to repossess performance studies is reflective of a desire among performers to recognise their own agency[5] in the actualisation of music—to feel not like 'laboratory subjects' (Rink in Davidson, 2004: 4) but 'artistic [and] intellectual equals' (Lester in Rink, 1995: 214). This desire is reflected in Spatz's question: 'How can practice be epistemic, if it may not be freely chosen?' (Spatz, 2015: 50). Such questions are timely and welcome as Performance Studies in music gains momentum within the wider Practice Research discourse. However, the orientation of many of Performance Studies' key arguments, which depend upon the separation of theoretical-*rational* analysis and performative-*intuitive* interpretation, fail to resolve a number of issues crucial to the cultivation of effective practice research.

At a most basic level, the theory vs practice dichotomy is problematic because it is suggestive of a community in which each individual does only one thing. This model clearly privileges professionalism in a very Western classical sense, as exemplified by Rink's statement:

> It must be stressed that 'performer's analysis' primarily takes place as an interpretation is being formulated and subsequently re-evaluated—that is, while one is practising rather than performing. (Rink in Rink, 2002: 39)

[4] Even the fiercest critics of theoretical analysis will entertain that published analysis can constitute practice. Lester, for example, references Jonathan Dunsby's statement that 'More often than not what the analyst is working on is his or her own "performance" in his or her head', while stopping short of validating Dunsby's accusation that these performances are 'more often than not second-, third- or worse-rate' (Lester in Rink, 1995: 212).

[5] As articulated by Rink, 'certain authors have all but robbed performers of their musical personae and artistic prerogatives, transforming them into museum curators, laboratory subjects, theorists and analysts, at the expense of their identities as musicians' (Rink in Davidson, 2004: 41).

Within the professional sphere, theorists who play instruments[6] and players who engage with theory (in any of the broadest senses of that term) are thrown into an ambiguous position; the insinuation that such individuals might have to choose to which kind of 'analysis' they adhere is indicative of the problematic nature of such a dichotomy. Meanwhile, students, amateurs, untrained practitioners, interdisciplinary practitioners, and indeed listeners are marginalised as practices which do not involve institutional learning and public presentation are left disqualified by the segregation of 'practice' and 'performance'.

For my own practices of intonation and microtonality, examined in this thesis and accompanying portfolio of recorded works, which might broadly be called 'experimental music'[7], the stylistic and aesthetic biases that accompany this segregation are particularly problematic. In many of these works, outcomes are indeterminate while internal processes are highly regulated. Public presentation of such works does not demarcate 'completeness', as the substance of the practice is contained within its own potential for discovery and transformation in re-enactment.

Recalling Spatz's notion that technique, as embodied knowledge, structures practice, as the instantiation of technique, any potential hierarchy that might be perceived between different moments of practice is reconciled through the refocussing on embodied knowledge. A player's first encounter with a musical work in the privacy of the studio is then ostensibly no more or less a part of their practice than any eventual public presentation of that work in a concert setting. Both moments of practice are structured by and productive of new embodied knowledge.

This view of practice is inclusive of a greater variety of artistic disciplines; however, it does not immediately preclude the suggestion that theory is 'rational' while practice is 'intuitive'. As Cook has shown, such a segregation will always place practice at a disadvantage through the privileging of research *outputs* that are easily rendered through discursive forms. Of this tendency, Borgdorff astutely remarks that 'the belief that art comes into being purely on the basis of intuition, on irrational grounds and via noncognitive routes' arises 'when the nondiscursive manner in which … content is presented to us is presumed to betray its irrationality' (Borgdorff, 2012: 14). In Performance Studies, such presumptions can have the unfortunate consequence of encouraging reactionary arguments that inhibit the 'epistemic impulse' (Spatz, 2015: 221). Joel Lester riles

[6] Cook notes that even 'Berry was [not] an ivory-tower academic: on the contrary, his book drew on his extensive experience as a composer (with two ASCAP awards) and performer (pianist and conductor)' (Cook, 2013: 42).
[7] Jennie Gottschalk's *Experimental Music Since 1970* (2016) provides a comprehensive overview of work and practice which might fall under this umbrella label.

against the ‘inherent superiority of cognition in creative performance’ (Lester in Rink, 1995: 198) and submits:

> Performers may not necessarily verbalise or even think consciously about these issues, even to themselves in the privacy of their practice studios. Nor do performers necessarily address themselves (whether consciously or intuitively) with the purpose of understanding how the piece is put together, how it 'works'…. That is, their goal is not necessarily to analyse the piece.… Indeed, many performers may be concerned with little more than achieving an 'effective' performance—one which pleases their sense of fancy and propriety (stylistic and aesthetic propriety as well as matters of stage decorum) and which is received by their audiences with approval. (Lester in Rink, 1995: 207)

Although these assertions support the player’s agency and almost certainly recognise the presence of embodied knowledge (in some capacity), Lester’s sole reliance on his notion of performative intuition amounts to little better than an anti-intellectualist sentiment. In order to ‘transform assumptions about knowledge both within and beyond academia’, Spatz (2015: 24) rightly argues that ‘we must do more than simply declare that particular performers or performance traditions possess embodied knowledge’. Failing to do so leaves Performance Studies starved for substance in an otherwise blossoming discourse on Practice Research.

Repetition, Experimentation and ‘Epistemic Things’

Spatz’s theory of technique as knowledge is robustly supported by Borgdorff’s argument that embodied practices, though (potentially) ‘nonconceptual’ are ‘cognitive’ and though (probably) ‘nondiscursive’ are ‘rational’ (Borgdorff, 2012: 15). Suggestions that players ‘work from note to note’ in ‘real-time’ (Cook, 2013: 45), in a ‘state of imminence’ (DeLio, 1984: 3), and that ‘performance’s being … becomes itself through disappearance’ (Phelan quoted in Spatz, 2015: 58) reflect what Spatz calls ‘an artefact of spectatorship’ (Spatz, 2015: 58). The appearance of spontaneity and the perception of inspiration in many embodied practices can conceal the extent to which embodied techniques are developed through *repetition*—and that the *repeatability* of technique can itself furnish methodological pathways toward the discovery of new practices. Anette Arlander reflects upon the ‘speculative’ nature of repetitive practices, writing:

> [C]reating a routine … is speculative in the sense of creating a basis for the unexpected to occur. Rather than speculate on alternative possibilities as a mental exercise, the speculation takes place by repeatedly creating the conditions for alternatives to appear, or not to appear, in and through the practice. (Arlander, 2017)

Although each instance of practice is 'bound to a specific time and place' (Spatz, 2014: 58) and is in this sense unrepeatable, Arlander's commentary illuminates the degree to which a practitioner can come to know a given path of practice, and its structuring techniques, over repeated *practising*. A given practice of intonation can at once reinforce technique, allowing for predictable, functional application, and expose unexpected new insights that advance the player's knowledge and the art form. The models of intonation technique presented in the previous sections illustrate observational (rational) and reflective (cognitive) processes, alongside enactive (manual) ones. A practice of intonation is thus able to transcend the immediacy of its own phenomenon, enabling technique to be developed and refined through reflective repetition (in the practice studio as well as on the stage), to be shared and mutually understood between practitioners (in collaboration and pedagogy), and to be applied in multiple contexts of further practice.

If repetitive practice can be speculative then it can also be *experimental*. Taking up the thinking of Hans-Jörg Rheinberger (1997), Schwab writes that 'experimental systems' can act as 'complex apparatuses for the production of knowledge' (Schwab, 2015: 122). For Schwab, experimentation holds its own 'distinct identity in the field of knowledge' because it implies both 'matter and discourse' (Schwab, 2015: 121)—making 'experimentation not only an epistemic project but also … deeply social' (Schwab, 2015: 122). A practice of intonation can qualify as an experimental system in that it exhibits its own matter (embodied technique, material technology) and discourse (practice, socially defined and symbolic meanings, pedagogy), and that it 'plays out its own intrinsic capacities' as the experimenter 'learns to handle his or her experimental system' (Rheinberger, quoted in Schwab, 2015: 122), until the system is 'able to surprise the experimenter with its own characteristics, unanticipated by the system's creator' (Schwab, 2015: 122).

In contrast to Rink's prior division of 'practice' (by which he means 'rehearsal') and performance—which brings to mind images of the solitary player as they fulfil requisite repetitions in expectation of the eventual realisation of a finished performance (a scenario with which many players can likely identify)—speculative, experimental practices such as those proposed by Arlander, Rheinberger and Schwab stand to incite profound epistemic shifts when

carried into the practice studio, the instrumental lesson, or the performance situation. Instead of practising toward completion, we may practice toward further embodied elucidation. With sustained repetition a player can test the boundaries and thresholds of their embodied knowledge[8], structuring these experiments 'so that the deployed knowledge results in ruptures from which unexpected new objects relevant to knowledge emerge' (Schwab, 2015: 122).

These discoveries, which Rheinberger calls 'epistemic things' (Schwab, 2015: 122), can afford the player new insights about the music beyond the practice of intonation. Sociologist Karin Knorr Cetina (2001: 181) similarly describes the 'epistemic objects' of practice research, which Spatz reflects are 'fundamentally incomplete', suggesting that 'their incompleteness is what challenges researchers and provokes them to research' (Spatz, 2015: 63). This 'vagueness' of epistemic things, for Schwab, 'represents a strength rather than a weakness, because epistemic things are first of all questions that promise a future (of possible knowledge)' (Schwab, 2015: 122).

At the intersection of these conceptual turns surrounding the speculative, experimental and epistemic capacities of practice, a string player's judicious placement of frequency may be positioned as an enticing field of Practice Research. Such an approach 'thus also repositions theory: theory emerges from experimentation rather than being tested by it' (Schwab, 2015: 122).

[8] As further explored further in Chapter 6.1, with the work of composer Martin Arnold.

Part 2. Ways of Knowing

3. Modelling Pitch Space

In Chapter 1, Marc Sabat's model of the *glissando continuum* of pitch height was introduced within a broader spatial metaphor of pitch. Through a string player's negotiation and manipulation of the glissando continuum, this notional pitch space is proposed as an arena for practice. This chapter explores further ways of modelling pitch space, representative of *tuning systems* which can be broadly grouped as 1) *Open-chain*, implying that pitches are generated through relational–iterative processes, and 2) *Closed-chain*, implying that pitches are generated through division of the octave.

These systems are represented both through mathematical (ratio) and representational (lattice structure) devices, and are discussed here because they furnish descriptions of pitch relationships that are distinct from those afforded by music notation. They are presented as relevant and vital to the practices discussed in Chapters 6 and 7 in that they represent conceptual models that can enable a player to extract generalised qualities and relational behaviours from specific musical contexts, and apply these broadly in practice.

3.1 Open-chain Tuning Systems

Open-chain or *non-circulating* tuning systems (Barbieri, 2008) derive pitches through relational iteration, beginning with simple, small-number proportions and progressing into higher-number, more complex relationships. This section will consider two primary examples of open-chain tuning systems, relevant to my own discussion of intonation technique: Pythagorean Intonation (PI) and Just Intonation (JI).

Before discussing properties and applications of these systems, it will be helpful to identify a means through which open-chain tuning systems can be represented and compared. Perhaps the simplest and most broadly applicable way is with *frequency ratios*, which can describe the proportional qualities of harmonic intervals. This present discussion is grounded in the ratio models of composers Harry Partch and James Tenney—whose lattice diagrams can effectively

illustrate the *harmonic spaces* (Tenney, 1983: 25) implied by open-chain tuning systems—as well as the application of these ratio models proposed by Marc Sabat.

Ratios express 'the vibrations per second, or cycles, of the two tones concerned, generally in the lowest possible terms' (Partch, 1974: 73). 'Natural intervals' can be represented as 'a *ratio of frequencies* [–] the simpler the pattern, the more consonant the resulting combination' (Sabat, 2009: 3). The *consonance* ascribed to small-number, or *low-order* ratios, has been an axiom of Western harmonic theory since Galileo contended that 'agreeable consonance' could be observed between tones whose vibrations were 'commensurable in number' (Partch, 1974: 138). Sabat elaborates on this definition of harmonic consonance:

> Consider two pitches, melodically close to each other, sounding simultaneously. As they approach unison, we perceive amplitude modulation or *beating* which gradually slows down. At a certain point, this beating is replaced by a phenomenon of spectral fusion *(perceptible periodicity)*, which may be likened to a focussing of the sound of the interval 1/1. (Sabat & Hayward, 2006: 3)

Partch colourfully describes how 'each consonance or comparative consonance is a little sun … around which dissonant satellites cluster' (1974: 151), while Tenney submits:

> since our perception of pitch intervals involves some degree of approximation, these frequency ratios must be understood to represent pitches within a certain tolerance range — i.e., a range of relative frequencies within which some slight mistuning is possible without altering the harmonic identity of an interval. (Tenney et al., 2015: 294)

More recent postulations about perceptually based interpretations of consonance have implications for string intonation technique, and will be discussed further in the following section.

String players find themselves uniquely enabled to absorb ratios into their modelling of pitch space because string instruments provide observable, tactile interfaces with a physical manifestation of low-order ratios: the harmonic series. Any open string of a violin may be taken as a fundamental frequency (1/1), while its harmonic overtones or *partials* display simple frequency ratios above that fundamental. The second partial of the violin's A-string, for example, divides the string into two equal vibrating lengths, displaying the ratio 2/1, an octave. Similarly, the third partial of the same A-string, dividing the string into three equal lengths, will sound a fifth above the second partial, displaying the ratio 3/2 (a Just fifth). In this manner, a string player may listen to any of the possible combinations of partials (within the material constraints of the

instrument, up to approximately the 12th partial), and come to know any of the low-order ratios related to the fundamental frequency of that open string.

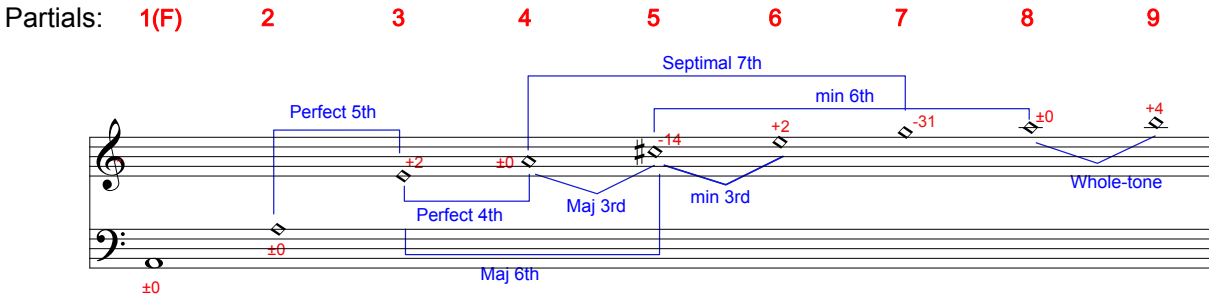

Figure 3.1.1 *Intervals that appear in the first nine partials of a harmonic series on A. Based on Christine Heman's diagram (Heman, 1964: 11)*

Low-order ratios describe the simplest versions of interval classes which also include more complex frequency relationships in other tuning systems. The region of tolerance of a familiar interval such as a major third may include a number of different frequency ratios (see Sabat & von Schweinitz, 2004).

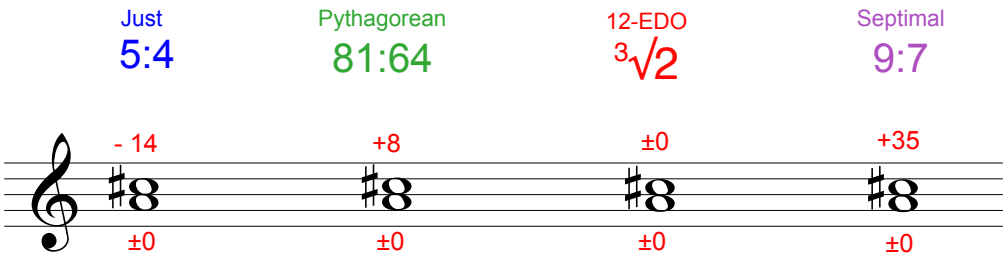

Figure 3.1.2 *Four different 'Major thirds', their ratios and cent deviations.*

When reading ratios as components of complex harmonies, or where there is more than one player involved in sounding an interval, it can be helpful to use *cent deviations*[1] to distinguish how the intonation behaviour of each independent voice contributes to the overall relationship. Innovated by mathematician Alexander J. Ellis in his translation of Hermann von Helmholtz's seminal text, *On the Sensations of Tone* (1885), cents modify Common Practice Pitch Notation to

[1] A cent represents 1% of a 12-EDO semitone, making the octave divisible into 1200 cents.

reflect the width of intervals with greater precision. Cents can reflect the intonation of single pitches as they deviate from 12-EDO, and imply their roles within potential low-order ratios.

Ratios are a particularly relevant way of modelling intervals in string playing, as they define pitch in relational terms that complement the intonation technique discussed in Chapter 1. Partch reflects upon the thickened context which ratio models can lend to the conceptualisation of pitch, writing:

> a ratio represents a tone and an interval at one and the same time; in its capacity as the symbol of a tone it is the over number that is nominally representative…, but since the over number exists only in relation to the under number, the ratio acquits its second function, as representative of an interval… (Partch, 1951: 73)

For example, the pitch class F on the violin's D-string (Fig. 3.1.3) could be imagined (among many other options) as a Just minor third (6/5) above the open D-string, or as a septimal seventh (7/4) above the open G-string. In both cases, the ratio gives the player information about the intonation of the F by defining its relationship to an open string reference pitch (1/1). Subsequently, this F might become the reference for another pitch, for instance, the B-flat a Just fourth (4/3) above it, which would be rendered very differently, depending on the original reference pitch.

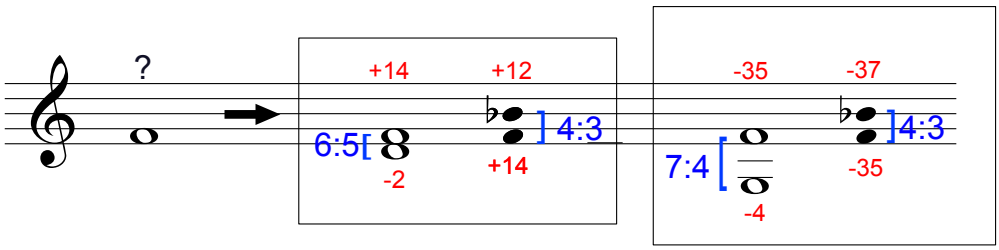

Figure 3.1.3 *Two versions of F on the violin D-string: tuned first at +14 cents as a minor third (6/5), from which a subsequent perfect fourth (4/3) gives a B-flat +12; tuned second at -35 cents as a septimal seventh on G, from which a subsequent perfect fourth (4/3) gives a B-flat -37.*

Tenney (2015: 295) submits that ratios are 'the appropriate language for the analysis and description of harmonic relations', proposing that, although 'pitch is usually conceived of as a one-dimensional continuum, like frequency' (Tenney et al., 2015: 368) a multi-dimensional harmonic space is in fact a more appropriate model. Tenney's models of harmonic space take the

form of *lattice* structures, in which 'the dimensions of the space … correspond to the prime factors required to specify their frequency ratios with respect to a reference pitch' (Tenney et al., 2015: 368).

The *limit* (Partch, 1951) of a harmonic space is defined by its highest generating prime factor, i.e., in an *n-limit* space all ratios contain no prime factors higher than *n*.[2] For example, a 2-limit space would constitute an octave (2/1) and multiples of its generating prime factor (2) resulting in a 1-dimensional axis of unlimited octave transpositions:

. . . 1/16, 1/8, 1/4, 1/2, 1/1, 2/1, 4/1, 8/1, 16/1. . . (Monzo, 2005).

Tenney rationalises that 'the number of dimensions of the implied harmonic space would correspond to the number of prime factors required to specify their frequency ratios with respect to the reference pitch' (Tenney et al, 2015: 295), but describes a means of simplifying any representation of harmonic space:

> there is a useful device … that invokes "octave-equivalence" and involves collapsing all the points whose labels differ only by a factor of the power of 2 into a single point, which then represents not a specific pitch (or interval with respect to 1/1) but rather a "pitch class". I call the resulting pitch space, which contains one dimension less than the original lattice, a *pitch class projection space*. (Tenney et al., 2015: 377)

The 2-limit harmonic space exemplified above can, therefore, be represented as a *pitch-class projection* of a single point: 1/1.

Ratio models facilitate the comparison of different open-chain systems without reliance on conventions of music notation, of which each different system carries its own biases. Additionally, ratios provide a framework through which to qualify and develop mutual understandings of those subjective characterisations of pitch space suggested in Chapter 1. Moving from lower to higher limits of harmonic space, a string player can, as Sabat (2005) describes, 'begin to investigate harmonic microtonality on acoustic instruments with confidence that [they] will readily be able to hear and reproduce [many] pitches'.

---

[2] Sabat (2006: 4) offers this helpful explanation: 'Following the musical terminology established by Harry Partch, we will define p_n [prime n] as the *limit* of the interval. For example, the interval 5/3 will be called a "5-limit interval", all natural intervals generated by the primes 2, 3, and 5 will be called the "5-limit set", and so on. The set of all p_n-limit intervals may be modelled using James Tenney's concept of *harmonic space* as an n-dimensional lattice with the primes $p_1,p_2,...,p_n$ as axes'.

Pythagorean Intonation

Pythagorean Intonation (PI), named after the Greek mathematician Pythagoras (6th century BCE) who is credited with the construction of the first Western scales, derives pitches through chains of ascending or descending fifths (3/2) (Barbieri, 2008: 5).

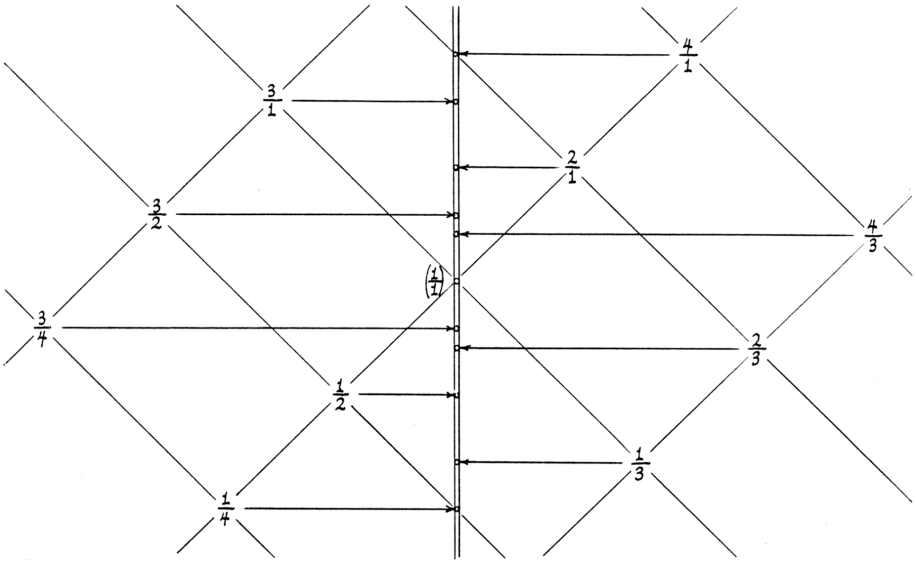

Figure 3.1.4 *Tenney's 2-dimensional 2,3 (3-limit) harmonic space (Tenney et al., 2015: 295)*

PI is, in Partch's terms, a 3-limit tuning system, consisting of intervals generated by the prime factors 2 and 3. The Pythagorean harmonic space can then be represented with Tenney's 2-dimensional lattice (Fig. 3.1.4) and as a 1-dimensional pitch-class projection plane:

. . . 128/81, 32/27, 16/9, 4/3, 1/1, 3/2, 9/8, 27/16, 81/64 . . . (Monzo, 2005)

A Pythagorean chromatic scale is obtained from a chain of twelve fifths (3/2), each with a width of 701.96 cents (frequently rounded to 702 cents in cent deviation notations), in contrast to the 12-EDO fifth of 700 cents. Therefore, whilst a circle of 12-EDO fifths closes after seven octaves, each circle of Pythagorean fifths exceeds seven octaves by a small amount, approximately one fifth of a 12-EDO semitone (Fig. 3.1.5). This discrepancy, the *Pythagorean comma,* can be expressed as $(3/2)^{12}/2^{7} = 1.014$, or a difference of 23.5 cents (Barbieri, 2008: 9).

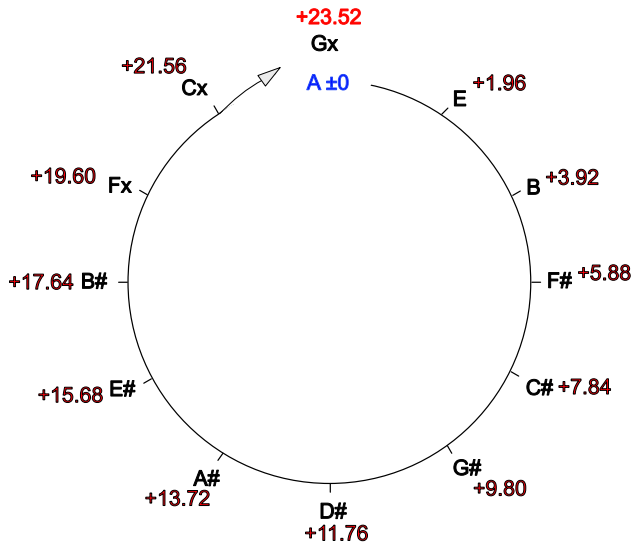

Figure 3.1.5 *Pythagorean circle of fifths with cents, starting on A(+/- 0)*

Fifths can be stacked above or below a reference pitch, projecting a circle of fifths into sharps or flats respectively, and the superimposition of these two circles will result in a *spiral* of fifths, in which each pitch is related to its *enharmonic* equivalent pitch by a Pythagorean comma of 23.5 cents (Figure 3.1.6).

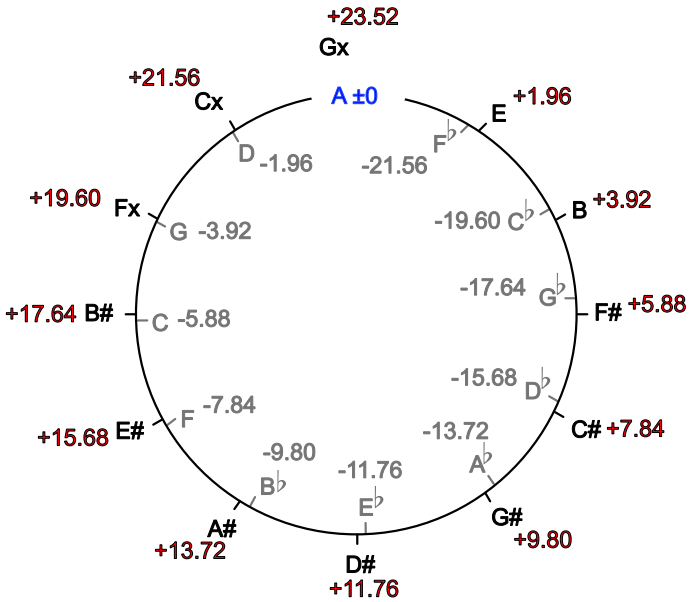

Figure 3.1.6 *Pythagorean spiral of fifths on A, through the sharps (outer clockwise chain) and through the flats (inner anti-clockwise chain)*

Enharmonic difference produces two sizes of Pythagorean semitone: *diatonic* semitones connect two pitch classes of different names (F#–G); *chromatic* semitones connect two pitch classes of the same name (C–C#) (Barbieri, 2008: 8). The diatonic semitone (S^D) has a width of 90.2 cents, and is the difference between the natural fourth (4/3) and the Pythagorean third (81/64): in cents 498 – 407.8 = 90.2 (Barbieri, 2008: 7). The chromatic semitone (S^C) is the sum of the diatonic semitone and the Pythagorean comma: 90.2 + 23.5 = 113.7 (Barbieri, 2008: 9).

Barbieri demonstrates (Fig. 3.1.7) how the building of a chromatic scale in sharps or flats will affect the relative sizes of each scale degree, 'given that in the Pythagorean scale $S^C > S^D$, the sharp will always be sharper than the enharmonically equivalent flat' (Barbieri, 2008: 9).

C	C♯	D	D♯	E	F	F♯	G	G♯	A	A♯	B	C
S_C	S_D	S_C	S_D	S_D	S_C	S_D	S_C	S_D	S_C	S_D	S_D	

C	D♭	D	E♭	E	F	G♭	G	A♭	A	B♭	B	C
S_D	S_C	S_D	S_C	S_D	S_D	S_C	S_D	S_C	S_D	S_C	S_D	

Figure 3.1.7 *Barbieri's two-size semitone comparison of Pythagorean chromatic scales through the flats and sharps, where S^D = diatonic semitone (90.2 cents) and S^C = chromatic semitone (113.7 cents). (Barbieri, 2008: 9)*

This reading of flats as lower than enharmonically equivalent sharps can carry ramifications for the mapping of the violin fingerboard, as well as the treatment of notated pitch in practice, as illustrated by early fingerboard maps and fingering patterns, such as those proposed by violinist Bartolomeo Campagnoli in 1797 (Fig. 3.1.8).

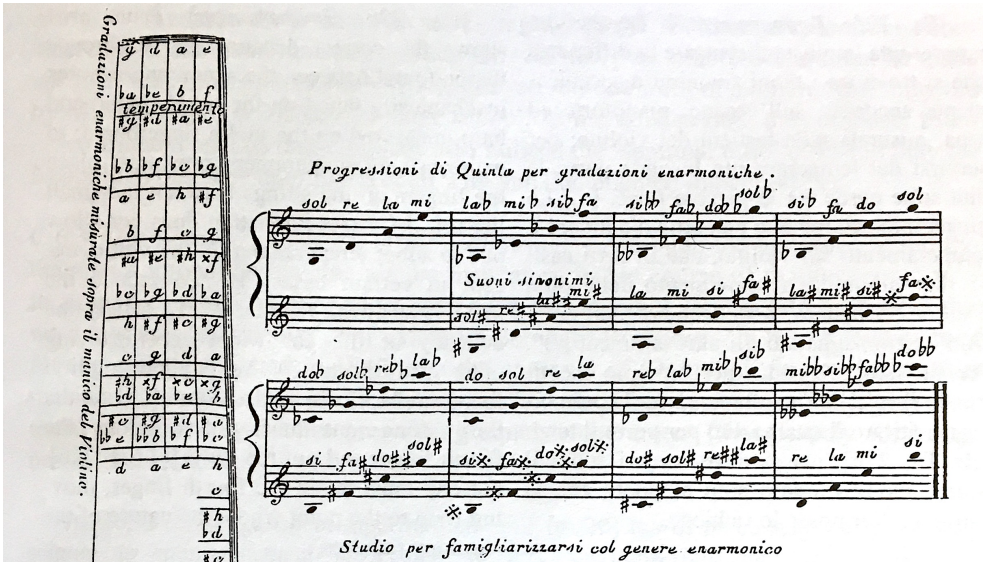

Figure 3.1.8 *Campagnoli's enharmonic fingering chart (Barbieri, 2008: 163)*

In practice, many string players (Heman, 1981; Sassmanshaus, 2004; Kimber, 2005; Saslav, 2008) have reflected on the appropriateness of Pythagorean Intonation as a model for *melodic* intonation—the relatively narrow diatonic semitones giving higher leading tones and a more pronounced difference between major and minor intervals. Additional correlations have been noted (Barbieri, 2008: 165) between the PI approach as seen in Campagnoli's method, and what has been called 'expressive–functional' intonation (Barbieri, 2008: 157)—a practice which gained popularity among string players in the 19th century, and further into the 20th century, as championed by cellist Pablo Casals (O'Malley, 1983). While historical tuning practices are not the focus of this research, the application of the expressive–functional approach will be further discussed in Chapter 4.

Just Intonation

Just Intonation (JI) derives intervals from whole-number ratios, and adds dimensions to the Pythagorean harmonic space by the inclusion of higher prime factors. The most immediate expansion results from the addition of the natural third (5/4), which is narrower and more consonant than the Pythagorean third (81/64) by a *syntonic comma* (81/80), or approximately 21.5 cents (Barbieri, 2008: 7).

A 5-limit JI contains ratios derived from the primes 2, 3, and 5, and can be represented as a 3-dimensional harmonic space (Fig. 3.1.9), or as a 2-dimensional pitch-class projection plane (Fig. 3.1.10).

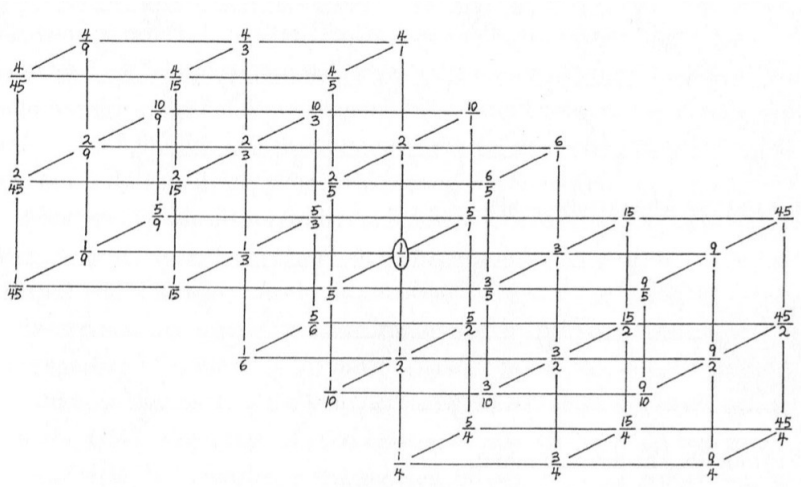

Figure 3.1.9 *Tenney's 5-limit 3-dimensional harmonic space (Tenney et al. 2015: 177)*

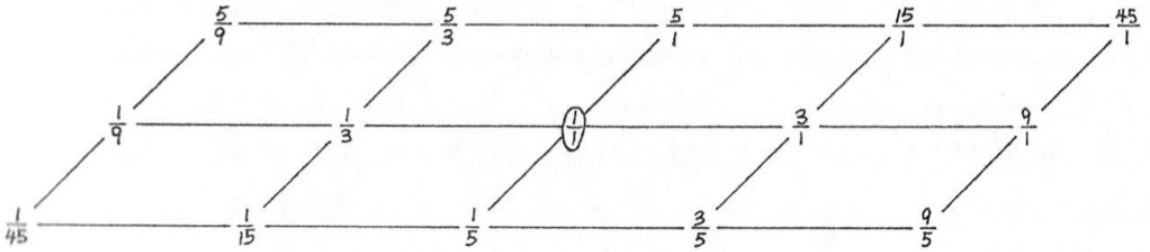

Figure 3.1.10 *Tenney's 5-limit, 2-dimensional pitch class projection plane (Tenney et al. 2015: 177)*

5-limit JI contains the primary intervals that form the basis of what Tenney (2015: 297) calls 'triadic/tonal music', as illustrated in the following two limited pitch class projections:

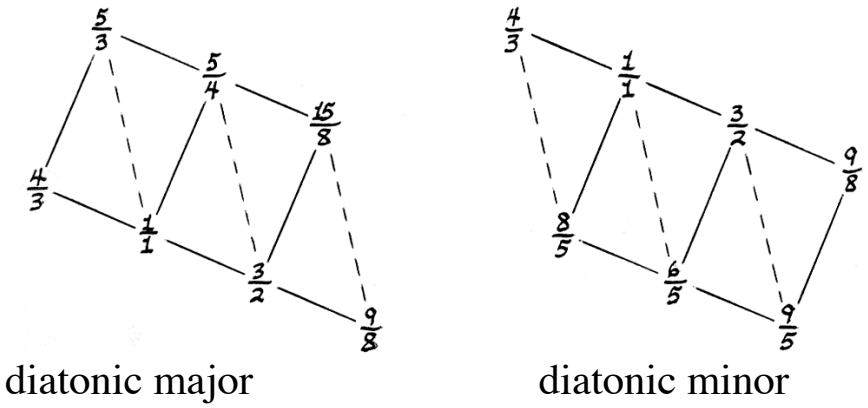

Figure 3.1.11 *Tenney's 'primary harmonic relations within the diatonic scales' (Tenney et al. 2015: 298)*

These two collections can be combined, and with the addition of two extra scale degrees—the minor second (16/15) and the augmented fourth (45/32)—form the primary harmonic relationships of the 12-tone chromatic scale:

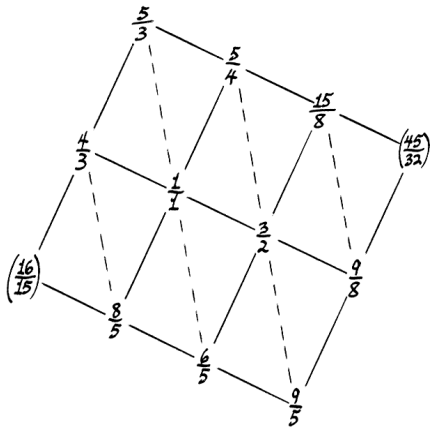

Figure 3.1.12 *Tenney's 'primary harmonic relations within the chromatic scale' (Tenney et al. 2015: 298)*

Moving into higher limits of JI, the inclusion of each consecutive prime factor necessitates an additional dimension or axis in representing the harmonic space. A 7-limit JI includes the primes 2, 3, 5 and 7, and would require a 4-dimensional harmonic space lattice, but can be represented as a pitch-class projection in three dimensions. An 11-limit JI occupies five dimensions in harmonic space—four as a pitch-class projection—and cannot be directly represented on the page, although recent interactive software, such as tuba player Robin Hayward's *Tuning Vine* (Hayward, 2012–18), furnishes effective extensions of the lattice structure into multiple dimensions of harmonic space.

String players have reflected on the appropriateness of 5- and 7-limit JI as models for *harmonic* intonation (Heman, 1981; Sassmanshaus, 2004; Kimber, 2005; Saslav, 2008), the low-order ratios giving consonant, non-beating simultaneities which tend to be considered 'in tune' by Western classical listeners. In current streams of practice, higher limits of JI have served as scaffolding for a broader scope of intonation practice, and now shine new light on received notions of consonance as rooted in the simplest proportional relationships.

In collaboration with Hayward, Sabat has proposed an expanded, perceptually based definition of consonance founded on the principle he calls *tuneability*: 'a consonant interval is one which may be precisely tuned by ear', while 'relative consonance may be described as the degree of difficulty in achieving a precise intonation' (Sabat & Hayward, 2006: 1). Sabat here draws on Tenney's *region of tolerance* principle in establishing his model of tuneability, referring to the slowing and ultimate stabilisation of beating as two glissando pitches approach a unison (1/1). An interval's region of tolerance can be marked by the player's perception that the interval is 'nearly in tune'

(Sabat and Hayward, 2006: 3), i.e., the interval sounds close enough to a low-order ratio to be counted within the corresponding interval class. A *tuneable interval*, in Sabat and Hayward's terms, is one which can be determined by similar means, using only the ear.

Sabat is careful to acknowledge that tuneability is not 'an absolute property', but rather depends variously on 'register, relative volume and timbre of the sounds', as well as on 'the experience of the listener' (Sabat & Hayward, 2006: 3). What is tuneable by one player is not necessarily tuneable by another. For a string player's technique of intonation, transformative potential may be found in the ability to distinguish between 'tuneable consonances', which can be directly tuned by ear, 'tuneable dissonances', which cannot be tuned directly by ear but which may be tuned 'through a succession of consonances', and intervals which are *not* tuneable by ear (Sabat, 2005).

An example of a likely tuneable consonance is the just third (5/4), which can be easily distinguished from other ratios within its region of tolerance by its distinctive difference tone and beating pattern, examined further in Chapter 6. As an example of a tuneable dissonance, Sabat proposes the following sequence of intervals:

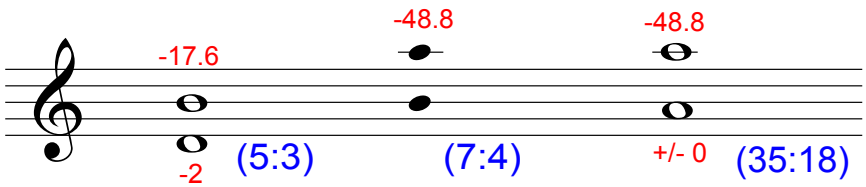

Figure 3.1.13 *'Play the open D-string together with B-natural one comma down (-17.6 cents) on the A string (1st finger, pure major sixth 5/3). To the comma-lowered B-natural, tune an A-natural lowered by a comma and a septimal comma on the E string (-48.8 cents, 3rd finger, natural seventh 7/4). Then play the open A string (0 cents) together with the lowered A (-48.8 cents). This is a beating, tuned "quartertone-diminished octave" with the ratio 35/18' (Sabat, 2005).*

Finally, among the 'un-tuneable' intervals, Sabat acknowledges many relationships which 'familiar usage allows us to play with acceptable accuracy', giving as an example that 'many instrumentalists can learn to reproduce the pitches of Equal Temperament, for example when playing with a piano' (Sabat and Hayward, 2006: 3). The sorting of intervals into categories of tuneability can help a player to form strategies around the audiation and recognition of pitches. Examples of the derivation and application of tuneable intervals in my own practice are explored in Chapter 6.

3.2 Closed-chain Tuning Systems

Closed-chain or *circulating* tuning systems (Barbieri, 2008) derive pitches by division of the octave into equal units, resulting in various Equal Divisions of the Octave (*n*-EDOs[3]). As Barbieri writes, an EDO has 'the advantage of perfectly resolving the problem of transposition, for it makes it possible to "circulate", i.e., return to the starting note after uniformly circumnavigating the whole circle of fifths' (Barbieri, 2008: 297). The familiar 12-EDO, ordinarily referred to as 'Equal Temperament'[4], is the most common among closed-chain tuning systems, and can be understood either as an equal distribution of the Pythagorean comma among 12 fifths (which narrows the ratio 3/2 by approximately two cents) or as a direct mathematical division of the octave (2/1) into 12 equal increments[5]. In either case, the frequency ratios of the 12-EDO can then be given as $2^{n/12}$, where n = 0,1,2…12 (Barbieri, 2008: 10).

Tenney considers that the 12-EDO gained widespread use 'not because twelve is a nice number to divide things up into (although it is that) … but because it can function as a fairly good approximation to 5-limit just intervals' (Tenney et al., 2015: 380). Barbieri notes that 12-EDO *fifths* are 'almost perfect' but that these in turn 'produce thirds that most musicians of the past centuries considered to be excessively altered' (Barbieri, 2008: 279).

Figure 3.2.1 shows the relative locations of the thirds, sixths, sevenths between PI, JI and 12-EDO scales:

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[3] *n* = number of equal increments into which the 2/1octave is divided, e.g., in a12-EDO, the octave is divided into 12 equal increments (colloquially, 'semitones').

[4] In this research context, I use '*n*-EDO' consistently because, as music theorist Joe Monzo describes, 'in certain cases this term is better than ET for describing equal-temperaments that are divisions of an 'octave' (assumed to be tuned to the ratio 2:1), because the 'octave' is not the only interval that may be evenly divided. For example, 19-tET or 19-ET, although they standardly refer to 2^(19/19), *could* mean 19 divisions of any pitch range, not necessarily an octave… [as evidenced] by the equal-tempered version of Bohlen–Pierce tuning, in which the 3:1 'perfect 12th' (that is, 'octave' plus 'fifth') is divided into 19 equal parts: 3^(19/19)' (Monzo, 2005).

[5] As Monzo notes, 'An important distinction between the use of "EDO" and "ET" is that composers do not always intend for an EDO to be a temperament of a just-intonation tuning. For example, in much 20th-century music, composers used 12-edo in a manner which does not refer in any way to its being a temperament of just-intonation—a good example of this is Schoenberg's "12-tone method"… In this compositional technique, the intervals of the 12-edo chromatic scale are not meant to represent tempered versions of the intervals of classic 5-limit JI, rather, the 12-edo scale is treated as a set of intervals with its own intrinsic properties unrelated to those of JI. Therefore, in this usage "12-ET" really does not give an accurate impression of the composer's intentions, and "12-edo" is preferred' (Monzo, 2005).

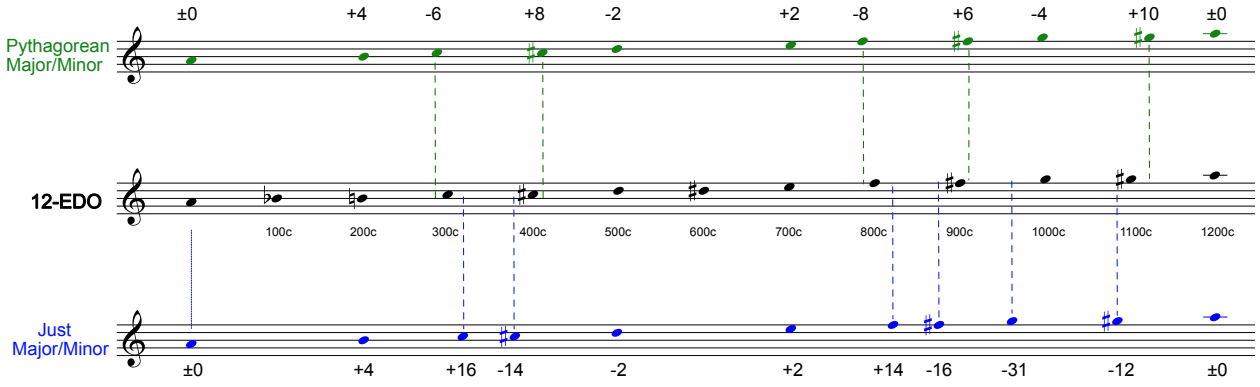


Figure 3.2.1 *Relative locations of pitches in PI, JI and 12-EDO scales (also see Appendix B)*

Tenney asserts that the region of tolerance of most diatonic intervals allows Western classical listeners to accept what he calls 'mistuned intervals' that result from the 12-EDO scale. He proposes that the ear 'would tend to interpret any given interval as … "representing"—or being a variant of—*the simplest interval within the tolerance range* around the interval actually heard' (Tenney et al., 2015: 379), and elaborates:

> a mistuned interval will still carry *the same harmonic sense* as the accurately tuned interval does, although its timbral quality will be different—less "clear" or "transparent", for example, or more "harsh," "tense," or "unstable," etc. […] Thus, when we play a major triad on a tempered piano, where the major third is 14 cents larger than the just third, we are "understanding" that the third has a 5/4 relationship… (Tenney et al., 2015: 379).

The *correctness* attributed to low-order intervals by Tenney could be a matter of debate. However, his argument does shed light on the incompatibility of tuning systems often experienced by string players attempting to achieve 'good' intonation while performing with keyboard accompaniment. Acknowledging this incompatibility, Barbieri (2008: 279) reflects that 'from the 16th century onwards many theorists tried to discover [an *n*-EDO] … that would produce consonances that were overall more acceptable than those produced by [the 12-EDO]'. A 19-EDO, for example, narrows each fifth by approximately one third of a syntonic comma (~7 cents), and produces minor thirds which are 'almost just' (Barbieri, 2008: 279). A 31-EDO produces *nearly-just* major thirds, and fifths narrowed by approximately 5.5 cents, or around a quarter of a syntonic comma (Barbieri, 2008: 279-80). A 72-EDO, which in common practice nomenclature might be called *twelfth-tone* Equal Temperament, contains a finer gradient of increments and allows for a close approximation of many 11-limit JI ratios (Sabat, 2005).

Naturally, Tenney's objective of identifying good approximations of low-order ratios within closed-chain tuning systems is not shared by every composer or practitioner of intonation. However, as Barbieri notes, an early motivation and practical application of closed chain tuning systems was that they facilitated the construction of fixed-pitch instruments, which needed to produce relatively consonant intervals whilst also being able to move between enharmonically related roots (Barbieri, 2008: 279).

Being more or less unconstrained by fixed pitches, string players might find lesser motivation (outside collaboration with fixed-pitch instruments) to pursue a practice of intonation rooted in closed-chain tuning systems, as the complex frequency relationships contained within many *n*-EDOs would be, by Sabat's terms, largely *untuneable*. In creative practice, some string players have explored closed-chain models of intonation practice and notation (e.g., Cubarsi, 2014). These investigations, however, fall somewhat outside the focus of this present research, for which the necessary perceptual mechanisms of intonation technique are more readily furnished by *open-chain* models of pitch space.

4. Paradigms of String Intonation Technique

This chapter examines intonation as it has been formulated and practiced by string players, questioning some of the underlying ideological and cultural contexts through which string players approach their practices and develop technique.

In string playing, the value of playing 'in tune' is virtually undisputed. Belief in the necessity of achieving 'good' intonation (e.g., Bang, 1919; Priester, 2015) is accentuated by widespread reflection on the inherent 'difficulty' of this pursuit (e.g., Spohr, 1848; Remy in Sevcik, 1922). Yet, in the ambience of Sabat's portrayal of the glissando continuum, or of Spatz's discussions of embodied knowledge—given the degree of choice involved in the sounding of any isolated interval, the seemingly infinite potential for intonational nuance in a complex musical score, and the many ways in which a player might come to know musical pitch through embodied technique—what do string players mean when they speak of playing *in tune*?

Convention and tradition certainly supply various broad dictates through which players come to recognise common patterns in tuned pitch. Most players, however, tend to agree that within the broad field of string playing, 'good' intonation may constitute many differing practices. As double-bassist John Michael Priester notes, '[o]ne of the major difficulties encountered when writing about intonation is that no consistent definition of "good" intonation exists' (Priester, 2015: 11). Priester (2015: 1) suggests that many string students 'proceed through their education without a clear understanding of what it is they are measuring and the manner in which they are measuring it', while violinist Goetz Richter (2013: 1) writes:

> While intonation is identified as one of the most central concerns for string players, agreement on what might define its quality seems by no means straight-forward or consistent. … While we reach fairly ready agreement about poor intonation we often remain silent about good intonation.

One possible reason for this sense of fuzziness surrounding string intonation is its implicit nature as represented in Common Practice Pitch Notation. The overwhelming majority of author-practitioners who contribute to the discourse rely exclusively on Common Practice Pitch Notation, both in their source material and in making their own examples. With the exception of

players such as Marc Sabat, whose practices engage expressly with 'extended'[1] harmonic languages, string intonation in all its nuance is comprehended, and more importantly *taught*, through a lens of twelve chromatic pitch classes. With access to formative historical tuning practices largely lost to modern players (Kanno, 2003; Duffin, 2006), discussions about intonation are tasked with apprehending nuance from something that is essentially vague.

Many players tend toward qualitative, descriptive language, which does not invoke any explicit method of modelling pitch space using tuning systems or other discernible measurements. In other words, string players are more likely to comment on the 'brightness' or 'roughness' of an interval, than they are to discuss its proportion as a frequency ratio, or the location of its pitches on the glissando continuum in cents[2]. Separated across continents, centuries, and divergent performance traditions, these descriptions can reflect a great many sonic identities.

Any attempt to trace a unified identity of string intonation must encounter the large body of instrumental treatises and pedagogical texts that have set out to reflect the practices of influential string players across the better part of three hundred years. Naturally, such texts represent only a small fraction of the individual practices that have contributed to the development of string intonation—indeed, many of history's most recognised players never published written exegeses, opting instead to teach one-on-one, or only to perform. However, among those players who have authored texts, a primary motivation seems to be to extend their own pedagogical spaces by presenting subjective and personal approaches to technique, rather than furnishing a notion of collective knowledge. As violinist Robert Jacoby aptly reflects, author-practitioners tend to concern themselves 'more with suggestions and opinions on the basis of their own reputations as performers than with any real effort to rationalise the subject' (Jacoby, 1985: 1). Literature of this nature can therefore provide a fair reflection of the variety and scope of practice present in string playing.

In examining a representative cross-section of technical and pedagogical string literature (historical and contemporary), certain inconsistencies and contradictions become apparent. Far from developing as a unified discourse, streams of practice seem to converge and then dissipate, suggesting a culture of individuals focused on ingenuity. The drive to innovate can, in some cases,

[1] 'Extended' tonality tends to refer to the implementation of prime-limit harmonic spaces beyond the 5-limit space that easily aligns with Western classical diatonic modes. Sabat's *Helmholtz-Ellis Extended JI Pitch Notation* practice, previously discussed in Chapter 3, accommodates intervals derived from pitch spaces up to 61-limit.
[2] It is worth noting that cents, while being virtually always associated with contemporary JI practices, have been available to players for nearly 150 years, having been proposed by Ellis in the 1875 edition of Helmholtz's *On the Sensations of Tone*.

promote incomplete research and unsubstantiated claims on originality. In what verges on a comically overstated example of this attitude, the influential pedagogue Carl Flesch prefaces his book, *The Art of Violin Playing,* with the following disclaimer:

> Only in certain specific cases have I indicated sources and literary references. …[I]t is of little importance for the non-historian to know who may or may not have been the first to have recommended one or another mode of procedure. For the same reason, so far as at all possible, I have avoided discussions with regard to authors whose opinions differ from my own. (Flesch, 1930: 5)

While Flesch cannot be assumed to speak for the majority of string players, his stance typifies certain dismissive attitudes, common among many author-practitioners, with respect to research and the intrinsic connections between their technique and related fields of knowledge.

Still, consistencies do appear between individual approaches, and are suggestive of several discrete paradigms that partition the broad umbrella of string intonation technique. Approaches within one paradigm favour the fixing of pitches according to scales or visual/haptic markers; those within a second paradigm foreground the relational capacity of pitch; those within a third paradigm prioritise the intuitive sensibilities of the player. These paradigms do not generally correspond to specific tuning systems or ways of modelling pitch space, but rather run concurrently with these concepts, which can be applied variously within each paradigm.

In order to make useful sense of what might or might not be ‘in tune’, this term must be situated and queried within some instances of its use. *Thematic analysis* (Braun & Clarke, 2006) offers an opportunity to situate my own speculative writings about embodied technique within those of others in the field. This kind of analysis is necessarily selective—it is not intended as an exhaustive collection of data, nor as an ethnography of string technique methodologies, which would fall outside the scope of this research. Examples are drawn from a nonetheless wide selection of literature by author-practitioners ranging from established authorities (e.g., Galamian and Flesch) to relatively lesser known contributors (e.g., Heman and Kimber). These various sources are treated with equal weighting in my analysis—a choice made with the understanding that it would limit engagement with aspects of cultural and artistic context surrounding the specific sources, in favour of emphasising patterns and commonalities that can thicken the description afforded by the term ‘in tune’.

This chapter thus contextualises my own practices amidst trends in string playing, and examines methods and preferences of individual author-practitioners within each of my proposed paradigms of intonation technique, questioning how themes in qualitative, descriptive language can reveal underlying processes and entelechies.

Ely et al (cited in Braun & Clarke, 2006: 80) note that any discussion of 'themes emerging' can

> be misinterpreted to mean that themes 'reside' in the data… If themes 'reside' anywhere, they reside in our heads from our thinking about our data and creating links as we understand them.

As Virginia Braun and Victoria Clarke contend, 'any theoretical framework carries with it a number of assumptions about the nature of the data, what they represent in terms of the "the world", "reality", and so forth' (Braun & Clarke, 2006: 81). My own thematic analysis is undoubtedly influenced by my core practice which, as noted in the introduction to this thesis, tends to regard repertoire and received practice from a non-normative position that typifies experimental music. I take a position that consciously (although not willfully) sets to one side some familiar principles from my own mainstream Western classical education—for example, generally accepted correlations between notions of 'accuracy' or 'correctness' and certain sounded pitch-regions and/or relationships—in order to reach a more rounded understanding of what it means to play *in tune* as a string player.

4.1 The Projected Fret

> 'Tis necessary to place the Fingers exactly upon the Marks that belong to the Notes; for on this depends the stopping perfectly in Tune.'
> (Geminiani 1754: 1–2)

Fingerboard tapes, fingering charts, and imaginary frets have been employed in technical methods throughout the history of string pedagogy. Practitioners who employ these methods tend to assume the principle that, of the pitches that are available to sound on the violin, certain are 'in tune' while the rest are 'out of tune'.

The presumption underlying the paradigm is that 'good' intonation is a matter of placing the fingers in specific locations on the string, although the rationale behind this spatial configuration

differs dramatically between practitioners. Despite the potential rigidness of this paradigm, it is by no means exclusively associated with equal divisions of the octave. Texts of this nature have reflected all manner of tuning systems, from Pythagorean and Just Intonations to the 12-EDO.

One of the earliest appearances of a fingerboard chart in a published violin method is found in Francesco Geminiani's *The Art of Playing on the Violin* (1751), generally considered the first widely published technical treatise for advanced string players.

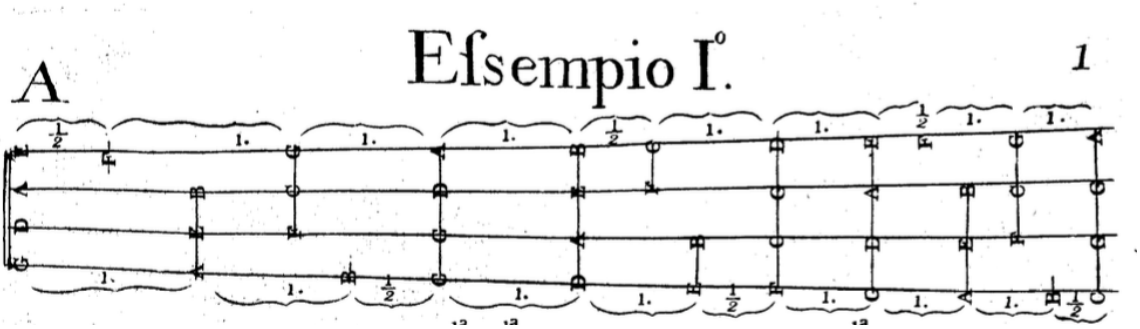


Figure 4.1.1 *Geminiani's violin fingerboard schematic 'A'*

Geminiani takes the view that playing in tune means learning the precise locations of the pitches along the fingerboard, and proposes the use of visual frets as an intonation aid, as exemplified by his fingering schematic (Figure 4.1.1). He describes its implementation:

> 'A' represents the Finger-board of a Violin, on which are marked all the Tones and Semitones, within the Compass of that Instrument, according to the Diatonick Scale… I would recommend it to the Learner to have the Finger-board of his Violin marked in the same Manner, which will greatly facilitate his learning to stop in Tune.
> (Geminiani, 1751: 1)

Geminiani's fingerboard schematic describes a fingering pattern that includes two sizes of semitone, 'that is, 7 of the greater and 5 of the lesser' , which the musicologist Robin Stowell concludes would have allowed for the 'differentiation between major and minor semitones according to harmonic function [which] was a significant expressive element in Baroque and Classical performance' (Stowell, 2001: 70). Clearly, Geminiani's approach takes into account the possibility of relational intonation, which is consistent with Stowell's observation that 'most eighteenth century tunings aimed to achieve fairly pure thirds and sixths' (Stowell, 2001: 73). It is reasonable to infer that Geminiani would have tuned intervals in some form of Just or mean-

tone tuning, as was standard practice at the time of publication (Duffin, 2007; Barbieri, 1991).

Nevertheless, Geminiani appears to prioritise a mechanical approach to fingering technique, as exemplified by his recommendation that students employ *silent* practice—repetitive training involving placement of the fingers according to his schematic, without bowing the string:

> It cannot be supposed but that this Practice without the Bow is disagreeable, since it gives no Satisfaction to the Ear; but the Benefit which, in Time, will arise from it, will be a Recompense more than adequate to the Disgust it may give. (Geminiani, 1754: 2–3)

Geminiani's method had a formative influence on the genre of pedagogical texts for strings, not least in that it established the scale as the primary method of training the left hand (Borup: 7). Such was its impact, Stowell remarks, that 'plagiarised versions continued to be published well into the nineteenth century and many treatises were based firmly on its principles' (Stowell, 2001: 21). From this point, and following Geminiani's example, fingerboard diagrams appear prominently in the pedagogy of string intonation.

Bartolomeo Campagnoli's *Metodo per Violino* (1797?[3]) (Figure 4.1.2) is widely acknowledged as the first violin method to illustrate and describe a Pythagorean-type tuning system (Stowell, 1985: 247; Barbieri, 1991: 82) in which sharps are pitched higher than their enharmonically equivalent flats (Boyden, 1951: 212).

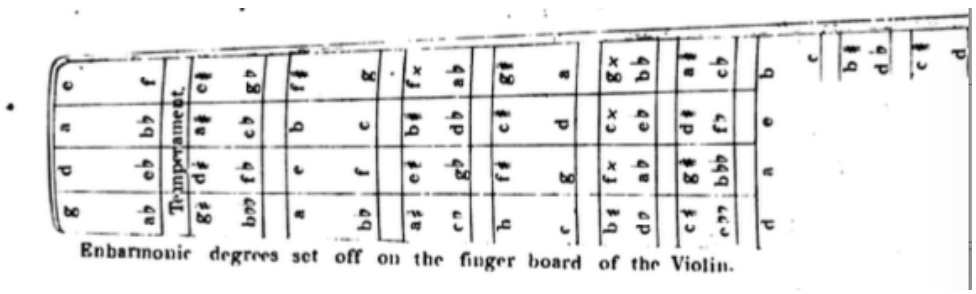


Figure 4.1.2 *Section of Campagnoli's fingerboard diagram, as published in Metodo*

Barbieri and Mangsen observe that Campagnoli 'preserved the enharmonic distinction between the sharps and flats, which [may be] made identical by the temperament only in a few exceptional cases' (Barbieri & Mangsen, 1991: 82). Campagnoli's fingerboard chart, described as follows, illustrates this option for intonational compromise, here referred to as the Temperament:

[3] The date of Campagnoli's original publication is unconfirmed, but Boyden cites 1797 in reference to A. Poth, *De Ontwikkelingsgang der Vioolmethodes* (Boyden, 1951: 212, fn. 19).

> In adopting the temperament, the fingers must be placed upon the strings between the little lines. […] Correctness of intonation prohibits temperament on the violin, except in certain cases: 1st, to lessen the movements of fingers, 2ndly, to satisfy the delicacy of the ear when accompanying other instruments, 3rdly, to facilitate performance; for instance when A-flat and G-sharp successively occur on the third string, it is not necessary to withdraw the fourth finger in order to employ the third, but the fourth must be kept pressed upon the string, and its position be modified as the nature of the harmony may require. (Campagnoli *trans.* Bishop: 1895: 16)

Campagnoli's explicit commentary on harmonic context sets him apart from many other proponents of this paradigm, yet his readiness to accommodate variations in temperament for reasons of practical facility pre-empts an ensuing shift among some practitioners toward a practice of string intonation more sympathetic to keyboard tunings. A leading proponent of this attitude was the violinist and pedagogue Louis Spohr. In his *Violinschule* (1832) Spohr rejects enharmonic differentiation in favour of 12 equally-tempered semitones. His preface 'to Parents and Teachers' defines 'pure intonation' as 'that which is according to equal temperament; for modern music, no other exists' (Spohr ed. Holmes, 1848: iii). Spohr continues:

> The subjects of unequal temperament, and of larger and smaller semitones, have not been mentioned in this School, as either would only serve to confuse the doctrine of the equal size of all 12 semitones. (Spohr ed. Holmes, 1848: vi)

While Spohr's method does not encourage the use of visual fingering charts, it does propose exercises for the player to establish the positions of pitches along the fingerboard by muscle memory and the building of a mental map of finger spacing. One such exercise stipulates:

> For the attainment of notes in perfect tune it is not sufficient merely to place the fingers mechanically in rotation. The intervals must be mentally measured, so that the stop of each note may become familiar, and the pupil may seek and find it as readily as the compositor his type. (Spohr ed. Holmes, 1848: 19)

In contrast to the works of Geminiani and Campagnoli, Spohr's method seems not to accommodate the notion of flexible intonation in any way. It is likely that Spohr was influenced by equal-tempered keyboard tunings, which at the time of his publication were becoming 'the widely cultivated norm for intonation in general' (Stowell, 2001: 72).

Figure 4.1.3 *Isidore Berger's violin fingerboard*

A number of early 20th century violin methods return to Geminiani's method of marking or measuring the fingerboard, but retain Spohr's equally-tempered semitone intonation. Violinist Isidore Berger's *One Hundred Fundamental Studies* (1913) features images of marked fingerboards (Figure 4.1.3), of which Berger writes:

> A correct mental conception of the exact places where the fingers must press the strings can best be seen when the fingerboard is marked off mathematically. The best method is to paste a fingerboard chart on the board. (Berger, 1913: 15)

Berger furthermore proposes a method of silent practice, which is reminiscent of Geminiani's, although Berger's commentary suggests he may not have been fully aware of the historical precedents behind the method:

> The old way is to teach by tones and half tones, depending entirely on the ear for guidance. The ear is really only a test… The arm and hand must be trained to make the exact spaces through the sense of feeling… the attention should not be confined to the ear alone… We recommend that all of these exercises be practiced silently… It is the Real Paganini Secret. (Berger, 1913: 15)

Published just prior to Berger's method, violinist Benjamin Cutter's *First Steps in Violin Playing* (1912) instructs:

> As a *tonal guide* the student should build a scale section… and carry out the other situations after this design, of course changing the starting tone as directed. This will insure intonation and help fix the pitch more definitely. (Cutter, 1912: 23)

Given the high degree of intonational rigour commanded by both authors, it is surprising that neither offers further clarification as to the sonic identity, or in Berger's case the 'mathematical' locations, of the exact pitches to which they refer. It is clear, however, that both authors treat intonation primarily as a physical imposition, which they aim to rein in by means of repetitive training.

Where some practitioners map the entire fingerboard as a whole, others instead focus on fixing or locking in smaller units of pitch. The noted violin pedagogue Leopold Auer had arguably one of the greatest influences on both the Russian and American schools of violin playing in the late 19th and early 20th centuries. His philosophies of performance and pedagogy are recorded in his book, *Violin Playing as I Teach It* (1921). Auer professes that 'faulty' intonation results from inadequate attention to the tuning of whole steps and half steps, and recommends scale-based practice, and for beginners, simple pieces with piano accompaniment to 'solidify the ear' (Arney, 2006: 51):

> Neglect of the half-tone progressions is at the very root of poor intonation—which does not mean, of course, the correct intonation of the whole-tone is not to be just as carefully cultivated. For distances between the intervals, already very slight in the first four positions, become impossible of measurement—even with the aid of a magnifying glass—in the positions above the fourth. Therefore try to secure from the very beginning the most perfect intonation of whole-tone and half-tone progressions. (Auer, 1980: 38–9)

Auer's vision of 'perfect intonation' imposes specific characteristics of intonement for each interval class. He prefers narrow tunings for semitones, stating that 'if the half steps are not sufficiently near each other, their intonation will always be dubious' (Auer, 1980: 38). Similarly, he rejects major thirds that are *too* narrow, since, as Lajos Garam observes, 'their use in playing diatonic scales necessitates also using broad semitones, which Auer considered to be the root cause of bad intonation in melodic playing' (Garam, 1990: 209).

Auer allows the exact proportions of broad thirds and narrow seconds to remain unspecified throughout his book. However, it seems that in this context he means them in contrast to the relatively narrow thirds and wide seconds found in Just Intonation. Violinist Hasse Borup notes that in addition to practicing diatonic scales, Auer 'strongly urges the player to practice chromatic scales as an aid for good intonation… [but] whether it is twelve equal half steps is not explicit' (Borup: 9). Auer's frequent references to the piano, both as a touchstone of aural training and as

an ideal model for articulation[4], may indicate a bias toward some version of equal temperament.

Following Auer's pedagogical approach, violinist Maia Bang's *Maia Bang Violin Method* (1919) once again features a fingerboard chart (Figure 4.1.4). Although published two years earlier than Auer's *Violin Playing as I Teach It*, Bang's method is advertised as providing 'Original Exercises and Suggestions by Leopold Auer and Based on his teaching Principles'. The text is punctuated by short quotations from Auer, confirming the virtues of each exercise.

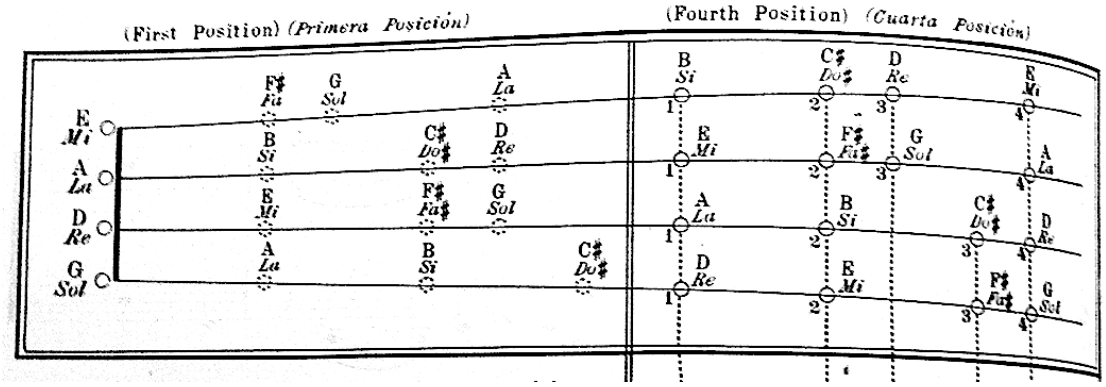


Figure 4.1.4 *Maia Bang's fingerboard chart*

Bang states emphatically that, of the 'major sins in violin playing, which the student should regard as taboo… [the first is] false intonation' (Bang, 1919: 194). Like Berger and Cutter, Bang does not elaborate on what qualifies a pitch as 'false', nor does she offer any precise indication of how a student might arrive at a conversely 'true' intonation. However, her discussion of double-stopping suggests a likely adherence to some moderate version of equal temperament[5]:

> It is advisable for the pupil not to begin to study double-stops before his intonation is securely enough established for him to be able to play every individual tone in a clean and perfect manner. When playing double-stops he is obliged to distinguish between two different tones at one and the same time and control them; hence, if his intonation is not perfect in single tones it will be still less so when he is playing two tones. (Bang, 1919, IV: 25)

[4] As evidenced in Auer's statement: 'The transition [between scale pitches] should be effected in a manner as completely inaudible and unnoticeable as is the legato movement from note to note… on the piano' (Auer, 1921: 34).
[5] Bang describes 'enharmonic change' as that 'in which two different tones are rendered identical in pitch through use of the [flat or sharp].' She then hedges this statement, stating: 'The tuning of a well-tempered piano renders these notes absolutely identical, although the perfection of intonation possible upon the Violin, enables an infinitesimal difference between the various intervals, for instance: F-sharp to be stopped slightly higher than G-flat.' (See: Bang, 1919, II: 45)

Bang characterises her double-stopping method in terms of discrete pitches—an unusual approach among string players, even within the tendency of the presiding paradigm toward fixed-pitch. It seems somewhat unlikely that in practice she would truly have played double stops by tuning each pitch individually, without regard for the intervallic relationship which is so audible on a bowed string instrument. However, it is easy to imagine how a literal reading of Bang's text might incite further polarisation within the discourse of this paradigm.

Whilst each of these author-practitioners brings a unique set of priorities and inclinations, certain methodological and linguistic commonalities point to shared values. Among these texts, words such as *exact, perfect, accurate, correct, pure* and *ideal* appear frequently in place of 'in tune', and their antonyms, such as *incorrect, false, poor,* and even *sin* take the place of 'out of tune'. This manner of language reinforces a polarised perception of intonation that is either *good* or *bad,* and promotes the development of practical methods that aim to 'fix pitch' and attain correctness.

The *manual* aspect of intonation technique is foregrounded in these approaches, to the extent that the form and action of the fingers becomes the primary object of observation, while the perception of pitch is little discussed if at all. Players are encouraged to form cognitive representations of fingering forms, but not necessarily of the sonority, quality, or behaviour of pitches and intervals. In comparison to the cyclic representations of intonation technique proposed in Chapter 1, the lack of a discernible reflective component in this paradigm is indicative of a rather more linear epistemic process (Figure 4.1.5). The preferencing of visual/haptic over over aural observation is a key factor in the absence of the reflective component in this paradigm.

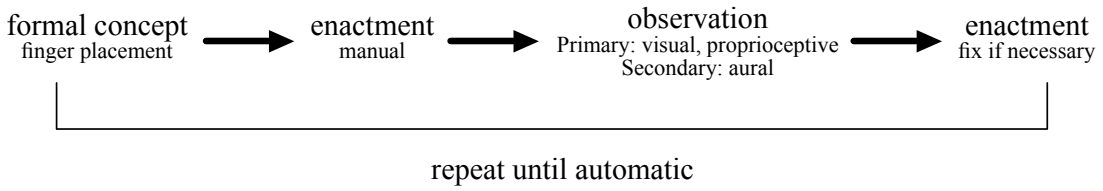


Figure 4.1.5 *Linear intentionality characterises The Projected Fret Paradigm*

To fully appreciate the subtleties of this paradigm, it is important to acknowledge that projected frets would have meant something very different to players before circa 1850, compared to

those in the later 19th and 20th centuries, and that this difference is reflective of other developments in music. For Geminiani and Campagnoli, whose performance repertoire would likely have occupied a limited number of idiomatic keys, fingerboard charts could depict the subtleties of voice leading and harmonic function in terms that a player might easily observe and internalise, thereby reinforcing intonation practices that defined the performance conventions of the day (Stowell, 2001: 73). For Auer, whose performance repertoire occupied a far more extensive tonal landscape, projected frets focused attention on the physicality of playing, and in utilising these methods players would be more likely to understand intonation technique in physical terms as well.

4.2 Relational Intonation

> 'Pure intonation on the violin is a complicated process, largely dependent upon tempering the individual intervals, [and] cannot be learned mechanically. On the contrary, perfect intonation is a matter of the intellect of the ear.' (Sevcik, 1922: ix)

Relational modelling forms the basis of many approaches to string intonation. Methods that occupy this paradigm generally aim to measure and design intonation according to local pitch relationships, as well as wider harmonic environments, and often define these measurements in terms of formalised tuning systems. Most relevant here are open-chain tuning systems, such as Just and Pythagorean Intonation, which can provide frameworks in which to negotiate iterative tuning processes.

Perhaps the most notable among early proponents of this paradigm was the violinist, composer and theorist, Giuseppe Tartini, whose *Trattato di musica* (1754) presents a wholly relational approach to violin intonation, rooted in Just Intonation.[6] Tartini's treatise is notable for his discussion of the *terzo suono,* or *difference tone,*[7] as an aid in developing intonation for the

[6] As Barbieri notes: 'Tartini unequivocally states that he strictly employed the syntonic intonation… [leaving the fifth] "where nature had placed it, without thinking of dividing it."' (Barbieri, 1991: 70)
[7] *Difference tones* are frequencies resulting from the difference between the frequencies of two or more primary tones. They are a sub-category of the larger family of *combination tones*—'the product of nonlinear, acoustic transmission systems' (Lohri, 2010: 97). A second sub-category, *summation tones*—are frequencies equal to the sum of the frequencies of two or more primary tones (Lohri, 2010: 97). The terms 'difference tone', 'combination tone' and 'third sound' are used interchangeably in English texts as translations for *terzo suono.*

player. The *Trattato di musica* contains the first full description[8] of the phenomenon and its implementation in practice (Stowell, 1985: 147). Tartini describes:

> When playing a two strings [sic] on my violin, where I can physically locate the ratio of the interval (for which the given third sound is a demonstrative physical sign), I have the advantage for myself and my pupils of secure intonation and, as a result, of the use of the [diatonic] scale in precise ratios. (Barbieri, 1991: 111)

Barbieri submits further evidence of Tartini's practice of Just Intonation, citing Francescantonio Vallotti's letter of 1751, in which the writer relates:

> I know that [Tartini] tunes the instrument with the most perfect fifths, and to his pupils he teaches their tuning with the assistance of the third sound, which, as we know, does not respond intelligibly except at the point of perfection. (Barbieri, 1991: 111–2)

Tartini's relational, aurally-based method presents a marked contrast to Geminiani's physically prescriptive method, published just three years prior, and this fundamental difference exposes the extent to which multiple philosophies of tuning practice have arisen and existed within contemporary communities of practitioners. Stowell notes that 'in spite of its inestimable value, discussion of the "third sound" is surprisingly neglected' by writers of treatises and practical methods, with significant discussion of 'the phenomenon, its consequences and examples of its application' (Stowell, 1985: 147) only appearing in Leopold Mozart's *Violinschule* (1756)[9] and in Pierre Baillot's *L'art du violon—Nouvelle Méthode* (1834).

Baillot's method undertakes a particularly thorough investigation of the benefits of the difference tone in practice, and includes examples of double-stopped passages with notated resultant difference tones (Figure 4.2.1).

He discusses the production and application of difference tones, and speculates as to their potential for wider use in practice:

> Whenever two notes are sounded together loudly, precisely in tune and sustained, the conjunction of resonant waves results in a third note… We have noted a remarkable effect which we present here as an isolated fact while giving an example of how it can be used to best advantage; it is quite

[8] Tartini is credited for discovering the difference tone in 1714, and is considered to have been the first to discuss its implications on the practice of intonation, although Stowell notes that an earlier description appears in G. A. Sorge's *Vorgemach der musicalischen Composition*, (1745–7). (See: Stowell, 1985: 147)

[9] Stowell (1985: 147) suggests that L. Mozart's method was heavily influenced by Tartini's treatise. Barbieri (2008: 111–2) offers further reference to Mozart's encouragement of students to check intonation using the 'third sound'.

> possible that one day it may form part of a general system such as the famous Tartini undertook to establish in accordance with his discovery of the 3rd note heard without any artificial means… (Stowell, 1985: 147)

Baillot confines this method to the tuning of isolated pitch relationships, and states, 'there is no need to point out that the third sound indicated on the 2nd stave presents here only isolated harmonies and not a harmonic progression' (Stowell, 1985: 147). In light of this distinction, the extent to which Baillot applied Just Intonation in the context of melodies remains open to interpretation. However, his discussion of scale practice includes '[scales] which are destined to establish good intonation *with regard to harmony*' (Stowell, 1985: 258) and from this comment it seems reasonable to assume that his approach to melodic intonation was at least informed by his concept of harmonic tuning.

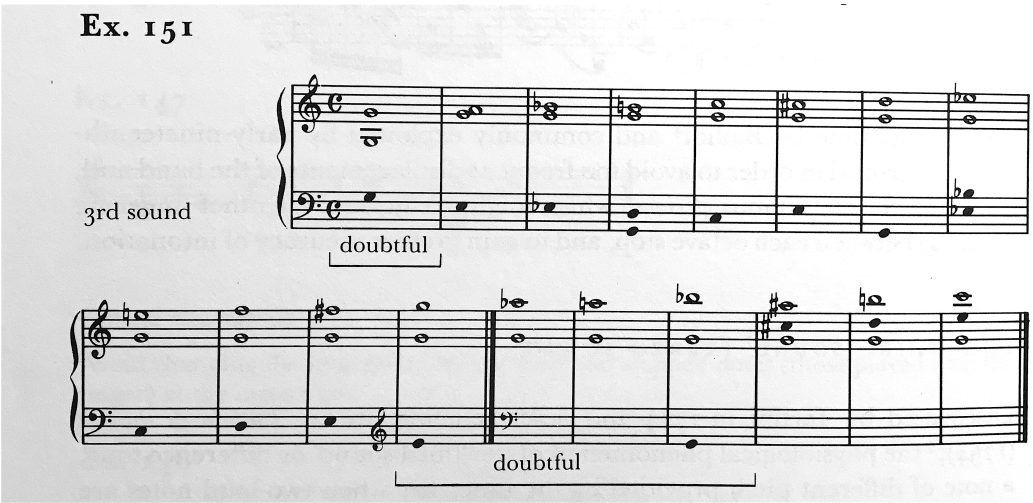


Figure 4.2.1 *A type-set reproduction of Baillot's illustration of intervals tuned in Just Intonation, using the audible difference tone method (Stowell, 1985: 148).*[10]

The topic of difference tones does appear in subsequent treatises by other authors, which demonstrates that players did employ the method, at least to some degree, as a practical tuning aid. One such player is Charles de Bériot, a prominent violinist, composer, and author of his own *Méthode de violon* (1858), who writes:

> True intonation in double strings requires an exquisite sense of harmony. In order to acquire this precious quality, the pupil must become familiar with those thirds and sixths which are consonant with the open strings G and D. These lower strings are only set in motion when the higher stopping is played with the most perfect accuracy; then a third sound is produced, which serves as

[10] Type-set from original illustration (Baillot, 1834: 22)

a regulator to the ear and to the position of the fingers. This true intonation of double strings once acquired will extend to all parts of the violin. (Hodgeson, 2014)

The celebrated violinist Joseph Joachim has been called 'the great master of just intonation in practical music' (Fuller-Maitland, 1905: 34), and his *Violinschule* (1905), co-authored with his student Andreas Moser, reflects this practice. An association with the physicist and psycho-acoustician Hermann von Helmholtz informed Joachim's approach to intonation, and the *Violinschule*'s introductory preface 'On the size of musical intervals'[11] presents Just spellings of diatonic scales (Figure 4.2.2) and the simple diatonic intervals as frequency ratios (Figure 4.2.3).

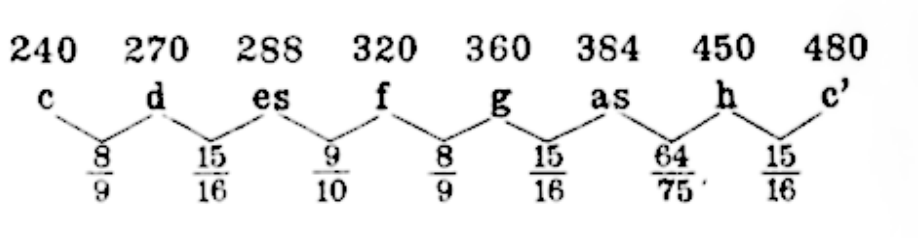


Figure 4.2.2 *Joachim's diatonic scale measured in Hertz and corresponding Just ratios (Joachim, 1905: 16)*

Konsonanzen:

1 : 2 = Oktave.
2 : 3 = reine Quinte.
3 : 4 = reine Quarte.
4 : 5 = große Terz.
5 : 6 = kleine Terz.
5 : 8 = kleine Sexte.
3 : 5 = große Sexte.

Dissonanzen:

24 : 25 = chromatischer Halbton.
15 : 16 = diatonischer Halbton.

Figure 4.2.3 *Joachim's Consonant and Dissonant intervals, and their corresponding low-order frequency* ratios *(Joachim, 1905: 16)*

Joachim's biographer, J. A. Fuller-Maitland, notes that his subject's intonation stood out among his contemporaries, dividing public opinion. Followers praised Joachim for playing 'far nearer the point of exact scientific truth than of any other violinist' (Fuller-Maitland, 1905: 33) while at once

[11] Translated from the German: '*Von der grösse der musikalichen Intervalen*' (Joachim, 1905: 15).

some critics remained unconvinced. Violist Michael Kimber reports that 'Bernard Shaw savagely claimed [Joachim] did not play in just intonation, but simply out of tune' (Kimber, 1974: 17).[12]

Despite these critiques, Joachim's pedagogical methods reflect his concern for relational intonation. In one instance, he calls into question the appropriateness of the C Major scale as a basis for establishing the violinist's left-hand position, and credits Charles de Bériot as having been 'the first to break through the old tradition' by instead teaching the G Major scale first, since 'the violin is a G instrument' (Joachim, 1905: 10).

While both de Bériot and Joachim allude to the use of open strings as tuning references, this principle is further explored in the writing of Otakar Sevcik, whose *School of Violin Intonation on a Harmonic Basis* (1922) comprises 14 volumes of relationally-based intonation exercises. Sevcik's method prioritises the open strings as centres of intonational gravity, around which all tuning decisions must be based. He rationalises this principle as follows:

> The practice of tuning the violin in perfect fifths is not without influence upon intonation on this instrument. From the necessity of tuning the violin in this manner has arisen the exigency that the individual tones of a scale must be produced differently, according as any specific tone forms an interval with an upper or a lower open string. Those tones forming intervals with an upper open string, must be produced somewhat higher than those forming intervals with a lower open string. (Sevcik, 1922: vi)

Sevcik does not disclose the meaning of 'somewhat higher' in more defined terms, and a curious reader might be motivated to seek further precision within the exercises themselves. Upon reflection, Sevcik's musical examples provide convincing evidence of an *adapted* version of Just Intonation. Sevcik's system groups pitches into two categories: 'Normal Tones' are pitches tuned to the lower neighbouring open string, forming intervals *larger* than a sounding fifth; 'Tempered Tones' are pitches tuned to the upper neighbouring open string, forming intervals *within* the range of a sounding fifth (Sevcik, 1922: viii). Following Sevcik's principle, those 'Normal' pitches should be tuned lower than those which are 'Tempered'[13] (Figure 4.2.4).

[12] In response to Shaw, Kimber remarks that 'If Joachim really did use Just Intonation in a melodic way, he may very well indeed have sounded out of tune' (Kimber, 1947: 17). This assertion is further explored in this chapter as it pertains to the *simultaneous/successive* intonation paradigm.

[13] Sevcik's idiosyncratic use of these terms, 'tempered' and 'normal' are discussed in conjunction with the writing of Christine Heman later in this chapter.

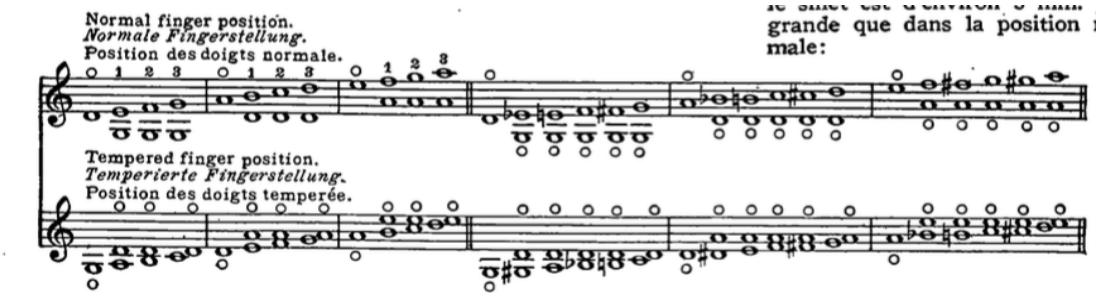


Figure 4.2.4 *'Normal' and 'Tempered' finger positions (Sevcik, 1922: viii)*

The following annotation (Figure 4.2.5) compares Sevcik's directive with interval sizes taken from a 7-limit Just Intonation, illustrating an overall correspondence.

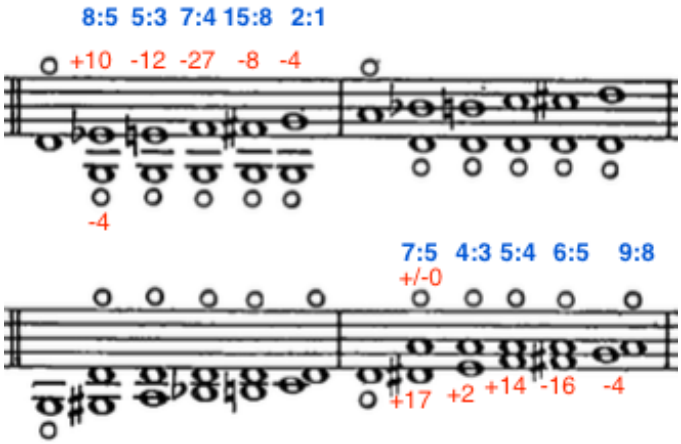


Figure 4.2.5 *JI annotation of chromatic pitches on the violin D-string, taken from Sevcik's 'Normal' and 'Tempered' fingerings (Sevcik, 1922: viii)*

This annotation takes Sevcik's two versions of the chromatic pitches above the violin's D string, tuned Justly against G ('Normal') and A ('Tempered'). Red cent deviations show the location of each chromatic pitch as it deviates from 12-EDO, while blue ratios describe the resulting Just intervals formed with each drone string. It is clear that a generally higher set of pitches results from tuning to A, while a generally lower set of pitches arises from tuning to G, and thus Sevcik's principle has been mostly satisfied. One notable inconsistency can be observed in the F-sharp, which here is tuned lower as 6:5 below A (at -16) than it is as 15:8 on G (at -8). One possible explanation is that F# functions as the leading tone in the key of G, and as such might in some practices be intoned higher in order to narrow the semitone between leading tone and tonic, with the goal of sharpening the profile of the key (see Barbieri, 1991: 82). The vagueness of Sevcik's terminology makes any interpretation speculative.

Clarification of Sevcik's objectives can instead be found in the trial and practice of his many musical examples. Through numerous descriptions of the sounding qualities of close position intervals, Sevcik illustrates his process of tuning pitches in Just Intonation to the surrounding open strings. In performing double-stops, he describes variable intonation depending on open-string context (Figure 4.2.7).

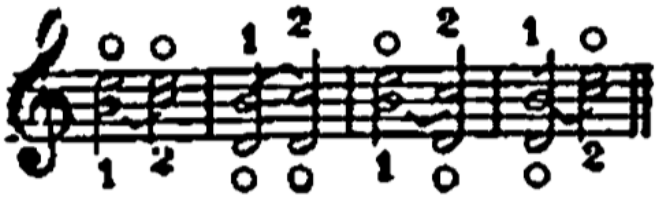


Figure 4.2.6 *Sevcik: 'the semitone (b-c) must be stopped slightly different in each bar. In the first measure the semitone is in the highest position; in the second, in the lowest; in the third it is the smallest semitone possible; in the fourth, the largest.' (Sevcik, 1922: vii)*

A JI annotation confirms that Sevcik's assessment of each interval placement is consistent with Just Intonation (Figure 4.2.7). In the annotation below, the B-E perfect fourth is tuned as the ratio 4:3, the C-E major third is tuned 5:4, the D-B sixth is tuned 5:3, and the D-C seventh is tuned 7:4. Corresponding red cent deviations describe the position of each discrete pitch. The size of resulting *linear* B-C semitone is illustrated in green, as it deviates from a 100-cent equally tempered semitone.

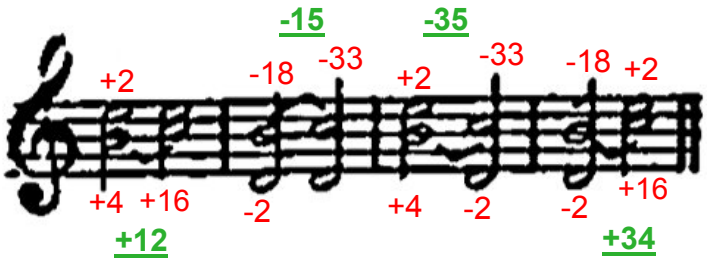


Figure 4.2.7 *JI annotation of Sevcik's schematic for semitone tuning (Sevcik, 1922: vii)*

Alfred Remy, whose commentary prefaces the English language edition of the *School of Violin Intonation on a Harmonic Basis*, praises the method as ground-breaking, stating, 'Professor Sevcik is the first to offer a scientific explanation of [the challenges of intonation] on the basis of the laws of acoustics' (Remy in Sevcik, 1922: iii). While this accolade is not in fact supportable, Sevcik's method is nonetheless noteworthy within its genre, as it proposes an

original, complete theory of violin intonation, stemming from the essential harmonic characteristic of the instrument—the open strings tuned in fifths.

Simultaneous / Successive Intonation

Sevcik's approach might be seen to tread a fine balance between the harmonic cohesion of Just Intonation, the physical imperatives of a string tuned in Pythagorean fifths, and the contextual demands of musical performance. This balance is itself the focus of a number of relationally-motivated approaches to intonation, which employ a purposeful mixture of different *tuning systems*, depending on context. Proponents of this sub-paradigm recommend contrasting strategies in the tuning of *simultaneous* (or harmonic) and *successive* (or melodic) pitch relationships—the former, it is contended, should be tuned in Just Intonation (JI), the later in Pythagorean Intonation (PI). The general principle, while more common among 20th century publications, was suggested in 1869 by French physicists Cornu and Mercadier, whose experiments led them to conclude that the Pythagorean and Just tuning systems, while incompatible in theory, could be combined effectively in performance (Barbieri 1991: 84).

Various terms have characterised these two models of intonation. These include: 'chordal' and 'linear'[14] (Heman, 1981: 10); 'static' and 'kinetic'[15] (Heman, 1981: 14); 'melodic' and 'harmonic' (Kimber, 2005: 1); 'simultaneous' and 'successive' (Heman, 1964: 14). The *simultaneous/successive* pairing suggested by Casals is most appropriate in the present study because it accommodates the widest variety of pitch contexts and allows for the discussion of pitches both in a musical context and in isolation.

Perhaps the most literal instance of this simultaneous/successive paradigm is offered in the pedagogical literature (2004—12) and accompanying instructional videos of violinist Kurt Sassmanshaus. His web resource, *Violin Masterclass – The Sassmanshaus Tradition for Violin Playing*, advocates Pythagorean Intonation as the basis of melodic playing, and Just Intonation for double-stops and chords. Sassmanshaus describes:

> [Pythagorean Intonation] provides us with the large whole steps and narrow half steps that lend expression to major and minor thirds, and to leading tones. (Sassmanshaus, 2004—12: Pythagorean Intonation)

[14] Original German: 'akkordischer and 'linearer' (Heman, 1981: 10)
[15] Original German: 'Statiche' and 'kinetische' (Heman, 1981: 14)

> Any scale, melody or passage with one line of music will sound cleaner with large whole steps, narrow half steps, large major thirds, narrow minor thirds, and high sevenths or leading tones. When we play double stops, we have to use Just Intonation. You will find that these two systems are not compatible, and sometimes you have to make choices and compromises. (Sassmanshaus, 2004—2: Which System…)

Sassmanshaus exemplifies one such compromise in Bach's *Sonata No. 1 for unaccompanied violin* (Figure 4.2.8), in which he argues:

> In the first chord […] the B-flat has to match the G on the E-string as a sixth in Just Intonation. In the following scale, the same B-flat needs to be played much lower, in the Pythagorean system—otherwise it will sound much too high. (Sassmanshaus, 2004–12: Which System…)

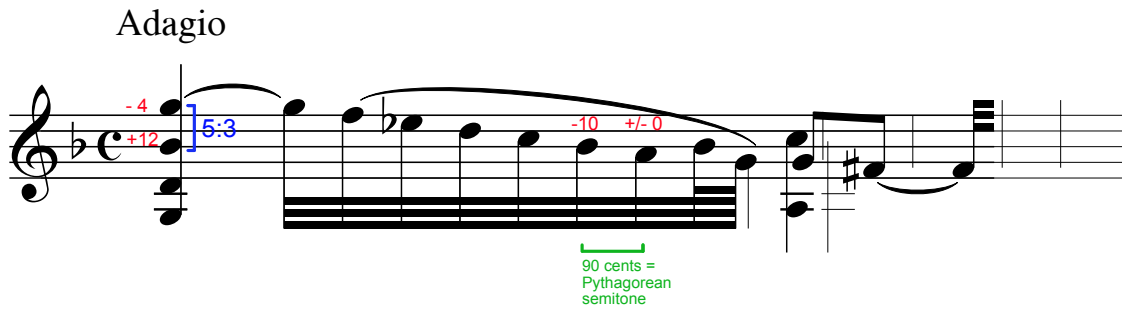


Figure 4.2.8 *Sassmanshaus' suggested intonation for the opening phrase of Bach's g-minor Sonata*

Sassmanshaus appears to draw much inspiration from Christine Heman's book *Intonation auf Streichinstrumenten: Melodisches und Harmonisches Hören* (trans. Intonation on String Instruments: Melodic and Harmonious Listening), published in 1964. Heman (1981:10) writes:

> …the ear measures distances within in a chord to be vertical, but it measures distances within a melodic sequence it to be horizontal. As our Western tonal system has gradually developed, the intervals, as chord components and linear sequences, are derived from the simplest vibrational conditions, which are, however, incompatible with one another. I would like to call these two different types of intonation "chordal" and "linear". (Trans. Shoshana Schwebel, August 2016)[16]

[16] Original German: *…das Ohr im Zusammenklang die Abstände in vertikaler, im Bewegungsblauf in horizontaler Richtung Mißt. So wie sich unser abendländisches Tonsystem allmälich entwickelt hat, leiten sich die Intervalle sowohl als Akkordbestandteile als auch im linearen Ablauf aus den einfachsten Schwingungsverhältnissen ab, die sich aber al unvereinbare Komponenten gegenüberstehen. (Heman, 1981: 10)*

Heman's book is part pedagogical text and part applied technical lesson, employing examples of fundamental tuning principles, formatted so as to be played as exercises on string instruments. Introductory chapters on common intonation errors and correction methods introduce readers to the Pythagorean and Just tuning systems, focusing on the major 3rd as a defining characteristic of each, and relating both to equal temperament. A substantial chapter on *linear intonation* concerns the application of the Pythagorean scale (Figure 4.2.10) in establishing melodic tuning. The following chapter on chordal intonation introduces Just Intonation, and discusses how the violinist may access the hearing of harmonic intonation by way of the harmonic series (Figure 4.2.9). Discussions of difference tones, performing with keyboard instruments, and the presence of consonance in modern music round out the text.

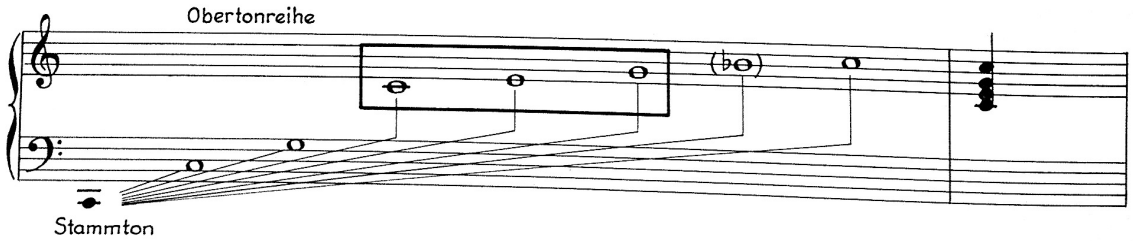


Figure 4.2.9 *Heman's Harmonic Series chord construction, showing triads derived from the overtone series. The fundamental* (Stammton) *and overtones* (Obertonreihe*) are seen to outline a C Major chord. (Heman, 1964: 10)*

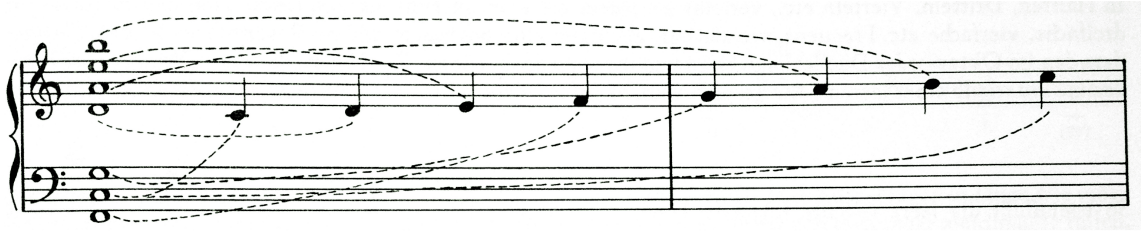


Figure 4.2.10 *Heman's Pythagorean scale construction, derived from stacked fifths (Heman, 1964: 19)*

Heman's book is by far the most substantial example of the simultaneous/successive paradigm, as well as the only published book to explicitly teach this method (papers by other authors discuss similar approaches in less detail). Heman takes the uncommon approach of using other players' published exercises in her own teaching (Figure 4.2.11)—a choice which serves to contextualise her method within the wider discipline.

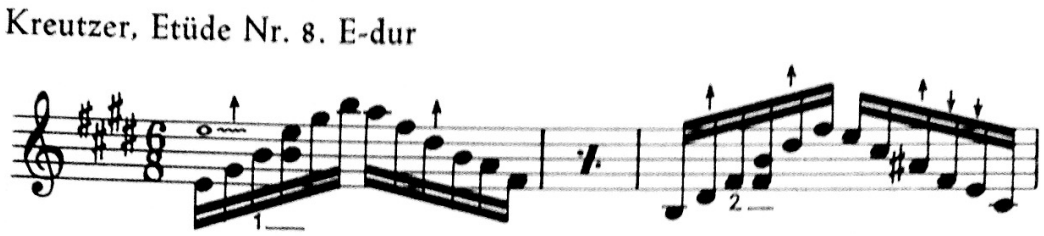


Figure 4.2.11 *Heman's annotation of intonation in a violin study by Kreutzer. (Heman, 1964: 32)*

Gratifyingly, Heman's book satisfies the predictions of Pierre Baillot, who 130 years prior mused that difference tones might 'one day' form the basis of a fully developed violin method (Stowell, 1985: 147). It is unfortunate that Heman's method, which so skilfully integrates lessons on harmonic theory with instrumental technique in a tenor that is inviting and accessible for new learners, remains without an English translation and out of print in its original German.

Heman's method has, however, garnered attention among string players invested in the topic, and violist Michael Kimber undertakes a thoughtful variation on Heman's approach in two papers entitled *Intonation: What Your Teacher(s) Never Told You* (2014) and *Playing Melodically and Harmonically in Tune* (2005). Kimber describes how a player may choose to follow either a Pythagorean or Just Intonation system, depending on context:

> When listening and playing melodically, we tend to follow the Pythagorean scale based on pure fifths (starting from our open strings); our sharps are a shade higher, our flats a shade lower, than in the scale of equal temperament. However, when we are more focused on harmonic blend, as in double stops and chords, we may favor just intonation, which actually involves some reversals of these Pythagorean tendencies. Because our music is a blend of melody and harmony working in tandem, *our intonation must weave an artistic path from one tendency to the other.* (Kimber, 2005: 2)

Kimber illustrates his comparison of the two tuning systems (Figure 4.2.12). In melodic intonation, Kimber suggests that the relatively higher sharps and lower flats of PI help to 'organize a framework of melodic pitch relationships [that emphasize] the distinction between major and minor intervals' (Kimber, 2005: 2), which can contribute to expressive contour in melodic lines. In the case of harmonic intonation, Kimber states that 'any time you play a double stop, your aim is to get it perfectly in tune—smooth, with no "beats"' (Kimber, 2014: 2). He proceeds to explore the 'harmonic adjustments that are sometimes necessary in ensemble playing with string instruments' (Kimber, 2014: 3). In one example, he proposes:

An A minor chord tends to sound best when it resonates with open A and E. However, whoever has the C, the third of this chord, may need to raise it up to, or at least up towards, C+.[17] Or, if this doesn't seem like the best solution, the violinists… may be able to relinquish THEIR open string rights and finger E and A a bit lower. We can even be courteous all the way around, and meet somewhere in the middle to get the intervals of the chord in tune. (Kimber, 2014: 3)

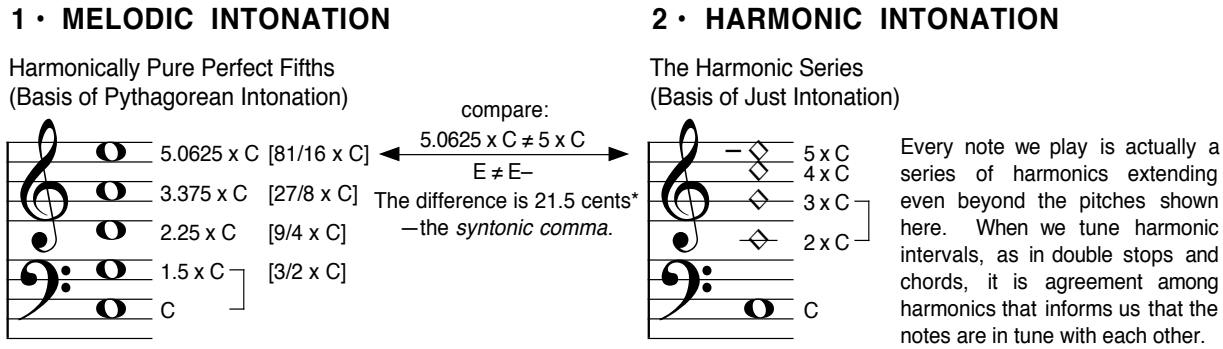


Figure 4.2.12 *Kimber's graphic illustration of Melodic vs Harmonic Intonation (Kimber, 2005: 4)*

Violinist Isidore Saslav explores a similar approach in his essay *How to Play in Tune on Stringed Instruments* (2008), in which the characterises 'the battle between the Pythagoreans and the Tartinians and how the well-tuned violin player has to pick his way carefully between the two camps' (Saslav, 2008: 7). Saslav proposes that 'Good intonation is based on, but not exclusively restricted to, the pure, tuneable intervals' (Saslav, 2008: 2), by which he means those simple forms of common intervals, which correspond to low-order ratios.[18] He demonstrates how a player can become familiar with the 'enharmonic alternative possibilities' (Saslav, 2008: 10) of each ascending semitone by forming Just intervals with all adjacent open strings. The method, which seems to be a variation on Sevcik's, aims to help the player navigate between tuning systems and make informed decisions in about intonation in performance. Saslav writes:

[17] 'C+' here refers to the Pythagorean comma, which Kimber summarises as follows: 'The Pythagorean comma, which results from tuning twelve pure fifths, causes sharps to be 24% higher than their enharmonic flats, a phenomenon consistent with melodic expressive tendencies, including but not limited to the "high leading tone." In melodically expressive *Pythagorean intonation* the differences between major and minor intervals are somewhat more pronounced than in equal temperament.' (Kimber, 2005: 3)

[18] The principle of tunability is further discussed in conjunction with the work of Marc Sabat (Chapter 3). With relevance to Saslav's above argument, Sabat has written: 'The process of tuning precisely is accomplished by listening to the periodicity of the composite sound and by paying attention to combination tones and beats. Tuneable intervals are always expressible as frequency ratios of natural numbers' (Sabat, 2006: 1).

> Accidentals come in two broad categories, decorative and modulatory… A decorative accidental serves to create a note which embellishes a normal step of the scale of the key established by the key signature without changing the key. Modulatory accidentals add or subtract sharps, flats, and naturals to notes which take the music to keys other than that of the key signature. For example, [imagine that] a piece printed with a key signature of two sharps is going along without accidentals when suddenly a bunch of **g**#s begin to appear. Are these **g**#s decorating the 5th degree of D major or are they taking the music to A Major? This decision is important for intonation. In general it's a good idea to squeeze the decorative half steps as close as possible to their main notes ("expressive intonation"). If a new key has appeared you treat it as you would with the Tartinian or Pythagorean methods you favor. In the example of the **g**# above, if it were decorating the *sol* of D you'd want to squeeze it closely to **a**. But if that **g**# now represents the *ti* of your A Major scale it's up to you to choose whether to squeeze it close to [‘A’] (Pythagorean) or tune it to [‘E’] as a just major 3rd (Tartinian). (Saslav, 2008: 24)

Saslav’s reference to *expressive intonation* acknowledges the influence of cellist Pablo Casals, who uses the term to define his own impactful approach to intoning melodic passages—which might be summed up, in Ross Duffin’s words, as ‘leading notes should lead’ (Duffin, 2007: 19). More precisely, expressive intonation implies a subtle exaggeration of the tendencies of Pythagorean intervals according to their melodic function, as described by Casals’ former student, cellist Pamela Hind O’Malley:

> Casals formulated this ‘expressive’ intonation, as it has come to be called, in the following way: […] major and augmented intervals become extra large, minor and diminished intervals extra small; the whole tone and the 5th have a tendency to be large, while the 4th and minor 7th tend to be small. (O’Malley, 1983)

Overall, this approach results in an exaggeration of the difference between major and minor intervals, which Casals implies can reinforce a listener’s impression of melodic expressivity (Blum, 1977: 103–10). O’Malley recalls:

> For [Casals] tone and intonation were indivisible. He believed that 50 per cent of a player's total expressive power lay in intonation. When asked what was the secret of his playing, he would say: “It is my intonation: I know where each note is to go”; and though he believed in knowing where each note should go on the fingerboard, he believed paradoxically that for each note there are many possible placings, to be determined by the context. (O’Malley, 1983)

The conductor and writer David Blum examines Casals' methods and motivations in his book *Casals and the Art of Interpretation* (1977). Blum describes Casals' approach to intonation not as 'a matter of adherence to intervals based upon a pre-ordained mathematical formula', but rather 'a dynamic process, expressing the organic relationship between notes in a musical context' (Blum, 1977: 102–3). Casals' approach to intonation takes a view sympathetic to the relational principle, in which 'intellectual awareness, intuitive perception and critical listening' (Blum, 1977, 106) all play a role in his technique. Yet his language, opinionated and rich in colourful metaphor, suggests a distinctly different paradigm of intonation technique, motivated by intuition and the expressive yearnings of the performer. As with all aspects of his practice, Casals' discussion tends towards the dramatic. He is reported to have once told a student:

> Intonation is a question of conscience. You hear when a note is false the same way you feel when you do something wrong in life. We must not continue to do the wrong thing.
> (Blum, 1977: 102)

The Relational Intonation paradigm embraces practices that vary widely in focus, priorities, and methodologies. Common among all these approaches, however, is the acknowledgement of *context* as an important factor in guiding a player's decision-making in the practice of intonation. In contrast to methods within the *Projected Fret* paradigm, references to 'out of tune' are far less frequent, while language used to discuss what is considered 'in tune' is often descriptive, prompting the reader to visualise a process alongside an outcome.

Among these texts, words such as *secure, precise* and *true* appear in place of 'in tune'. *Perfect* also appears, but is most commonly used in reference to intervals, for which a system of measurement is generally specified. Discussions of intonational *accuracy* tend to be qualified by musical examples, and for the most part refer to the fitness of a tuning within its harmonic role, or the function of a pitch within the musical environment.

In contrast to the Projected Fret paradigm, practitioners of Relational Intonation prioritise aural observation—the implication being that a cultivated practice of listening can facilitate other elements of technique. Embodied reflection, which occurs between observation and enactment—and in which the creative interplay between abstract models and immediate bodily information can take place—is generously accommodated by the relational approach. As such, this paradigm aligns most closely with the cyclic representations of technique represented in Chapter 1.

4.3 Intuitive Intonation

> 'I can't tell you what it is, but I know it when I hear it.'
> (Priester, 2015: 11)

The *expressive intonation* of Pablo Casals, discussed in the previous section, might be regarded as a bridge linking Relational Intonation with another paradigm, one driven by intuition. Expressive intonation, whilst attentive to context, is primarily motivated by a performer's intuitive sensibilities, formed in tandem with a deeply internalised embodied knowledge of their instrumental sound. Its guiding principle, as expressed by O'Malley, is that 'everything depends on the ear' (O'Malley, 1983/2017).

For many players intuition is the driving force behind any practice of intonation, and these practitioners tend to draw a distinction between intonation as theoretical ideal and intonation as functional technique. Methods within this paradigm acknowledge the acoustic characteristics that might instil in a listener the impression of in-tune-ness, yet treat these as ideals that are unattainable in practice. Rather, it is suggested that the practical solution lies in creating the *impression* of perfect tuning.

The writings of Carl Flesch and Ivan Galamian, two of the 20th century's most influential violin pedagogues, clearly define this paradigm. Of the two, the earlier was Flesch, who published *The Art of Violin Playing* in 1923. His perspective on intonation might be summed up with his statement:

> There is absolutely nothing disgraceful about placing the fingers inexactly on the strings, if only the note is so rapidly corrected that the listener is unconscious of the original, incorrect pitch. (Flesch, 1930b: 21)

Flesch was aware of Helmholtz's research in acoustics, which he references in his preface to *The Art of Violin Playing*:

> According to acoustic law, each tone has an exactly defined number of vibrations. When these are produced in the quantity prescribed, we feel and describe the resultant tone as being *true*, or "in-tune," and in the contrary case as being *false,* or "out of tune" … Hence, *playing in tune* would mean that we "take" the notes in that place where the shortening of the string secures a certain number of vibrations mathematically determined in advance. (Flesch, 1930b: 20)

It is evident from Flesch's references to 'vibrations' that his concept of what is in tune accommodates aspects of relational hearing, and likely aligns with the beat-free consonance of low-order intervals. However, his characterisation of fingering at points 'mathematically determined in advance' implies a somewhat simplistic view of the reciprocal dynamics of these open-chain tuning systems, and Flesch questions whether it is truly possible to play 'mathematically' in tune. Upon calculating the number of Hertz per millimetre of the violin fingerboard, and reasoning that each finger must be placed 'at so true a point as not to vary 1/6 of a millimetre' Flesch concludes (1930b: 20) that 'in the physical sense, "playing in tune" is an impossibility'.

Flesch's solution to what he considers to be 'the problem of *purity of intonation*' is to take a rather less quantifiable approach:

> Yet there are a number of violinists who create the impression of playing in tune. How are we to explain this apparent contradiction? By the simple fact that these violinists, though they do not strike the note exactly, do *correct* it during the fraction of a second, either by shift of position or by means of *vibrato* which approximates the *true* note. All this, when the player is correspondingly skilful [sic], takes place so rapidly that the listener feels as though the note had been *true* from the very beginning… *Hence what we call "playing in tune" is no more than an extremely rapid, skilfully* [sic] *carried out improvement of the originally inexactly located pitch. When playing "out of tune" on the other hand, the tone, as long as it sounds, remains as false as it was at the moment of its production*. (Flesch, 1930b: 20)

Flesch's comments regarding the impact of vibrato upon pitch precision offer some further indication of a preference for low-order intervals. He recommends that a player should practice 'without vibrato, and if possible with the aid of the corresponding open string, until he is absolutely convinced that he has reached the correct pitch' (Flesch, 1930b: 21). As previously elucidated by Sevcik, this approach exposes the beating patterns and combination tones that sound most readily in low-order intervals. However, Flesch rejects further logical extensions of this approach. Of the difference tone, earlier explored in the works of Tartini, Baillot and Heman, Flesch asserts:

> As to the so-called *combination-tones,* discovered by Tartini […] I find it impossible to regard them as very important from a practical point of view. [It is true that] a knowledge of their existence supplies an effective means of control for purity of double-stop intonation. One should be in a position, however, to be able to judge as to the latter even without more detailed

> examination of the combination tones. They offer [...] an indirect means of securing purity in interval-playing, and may be said to represent the substitution of a mechanical procedure for purely personal responsibility. (Flesch, 1930b: 22)

Notwithstanding certain obvious contradictions that convolute this statement, Flesch offers no alternative means by which to gauge the accuracy of double-stop intonation, nor does he elaborate on the implications of 'personal responsibility'. In the context of Flesch's complete practice, his rejection of Tartini's difference tones seems arbitrary. That Flesch also rejects Tartini's writing as a reference on historical trills (Arney, 2006: 56) could suggest a broader bias against Tartini's work on the part of Flesch.[19]

Flesch's influence on 20th century violin playing was unquestionably profound, and his pedagogical philosophies are echoed widely in the works of many other practitioners. One such violinist is Ivan Galamian, whose renowned pedagogy formed the backbone of American violin playing in the latter 20th century. His perspective on intonation technique is outlined in *The Principles of Violin Playing and Teaching* (1962). Galamian shares Flesch's concept of creating the impression of good intonation through micro-adjustments of pitch, which he describes as follows:

> [The player] should have the ability to make instantaneous adjustments in his intonation. (The best and easiest way to make such adjustments is by means of the vibrato.) An intonation adjustable to the needs of the moment is the only safe answer to the big question of playing in tune. (Galamian, 1962/85: 22)

Galamian advocates an integration of haptic and aural intuition, stating that 'the building of good intonation rests mainly on the sense of touch in combination with the guidance of the ear' (Galamian, 1962/85: 20). On the development of a practice of intonation in complex repertoire, Galamian suggests:

> Eventually, this skill develops to a point where the mere act of mentally preparing the movement and thinking the sound of the desired pitch will be sufficient to cause the fingers automatically to hit the right places on the strings with accuracy […] Advanced players, already in possession of a secure intonation, will find that their facility for quick adjustment

[19] Flesch was known to dismiss the work of other pedagogical innovators. He criticised Sevcik for relying too heavily on repetitious exercises, while launching a full-scale attack on Andreas Moser, describing his publications as 'practically inexperienced and reactionary' and Moser as 'one of the weakest violinists to emerge from the Joachim school'.

> can be further improved by changing from time to time the instruments they use […] One should be able to play *in tune* on a violin which is *out of tune.* (Galamian, 1962/85: 20–22)

Like Flesch, Galamian's approach to intonation was informed by an understanding of acoustics and tuning systems, and he similarly believed this knowledge could be applied only superficially in practice. Galamian writes:

> Lastly, in this discussion of intonation, it is necessary to consider what type of intonation ought to be used: the "tempered" or the "natural." This is not the place to go into the technicalities of the two systems. No violinist can play according to a mathematical formula; he can only follow the judgement of his own ear. Be this as it may, *no one system of intonation will suffice alone.* A performer has constantly to adjust his intonation to match his accompanying medium. (Galamian, 1962/85: 22)

An experienced reader might understand this statement to mean, simply, that the aural and manual components of a violinist's embodied technique develop in tandem, and are inseparable in practice. Indeed, much of the discussion of intonation held by both Galamian and Flesch might be summarised as such. Throughout each of their writings, there is a general tendency away from explicit discussion of observation strategies, and towards the depiction of a deeply embodied, but decidedly un-reflective practice.

While the emergence of this paradigm certainly cannot be attributed solely to these two practitioners, it does appear more prominently in published works in the wake of their teachings. Many subsequent works of pedagogy make fewer references to intonation altogether, while other areas of technique such as bowing and sound production gain greater prevalence. In the works of Flesch and Galamian the correspondence between in-tune-ness and low-order intervals is strongly implied, if not stated outright. In the works of some subsequent practitioners, however, the objectives of intonation technique are assumed to be universal and absolute.

Robert Jacoby proposes that the visual ambiguity of string instrumental technique 'has contributed historically to the unconscious conviction of many writers that violin playing is peculiarly a matter of inborn ability […] rather than the outcome of a clear-cut technical approach' (Jacoby, 1985: 2). His *Violin Technique – A Practical Analysis for Performers* (1985) sets out to 'construct a rational basis for violin technique' (Jacoby, 1985: 1), but ironically exemplifies some of the same 'unconscious convictions' he aims to resolve, at least where intonation is concerned. The text presents a detailed commentary on the mechanics of *bowing*,

sound production, *vibrato*, *shifting*, *agility*, and the application of technique to repertoire, however a devoted discussion of intonation is notably absent. Some reference to intonation takes place within a chapter entitled 'Accuracy and gymnastics', in which 'accuracy' signifies in-tune-ness. Jacoby (1985: 50) states that 'the requirements of intonation and agility relate to the same areas of muscular activity in the left hand' and offers examples of passages from violin repertoire, in which agility is more, less, and equally important to intonation. It is clear that he regards technique as distinctly manual, and intonation as a peripheral result of facile movement on the instrument.

Elsewhere in the text, it is apparent that Jacoby's sparing discussion of intonation stems from certain assumptions about inherent qualities of in-tune-ness. He states:

> The degree of analysis required in understanding the exact nature of any particular aspect of violin technique is proportional to its obscurity. Thus the more intangible, less obviously identifiable problems of right-arm technique demand the most detailed examination while, on the whole, the issues which arise in considering the left arm tend to be more accessible and generally clearly defined. If, for example, a note sounds bad because it is out of tune, an appropriate adjustment of the finger concerned will undoubtedly put matters right. (Jacoby, 1985: 36)

Jacoby uses the words 'bad', 'out of tune', 'appropriate adjustment' and 'put matters right' without any discussion of what these mean in his practice context. While it is more than likely that he subscribes to some version of common-practice consonance, his lack of specificity on the subject within an otherwise detailed monograph is conspicuous, and suggests that Jacoby assumes prior knowledge of intonation technique on the part of his readers. An inexperienced reader in search of concrete guidance, as the book purports to offer, might justifiably be left with questions about how to proceed.

When reading texts such as Jacoby's, a player must rely to a considerable extent on their own received practice. Given what might be argued to be an anti-intellectual bias in this paradigm, and the prevalence of the apprenticeship model of teaching in string playing (Crispin in Dogantan-Dack, 2015: 53), it is perhaps not surprising that many practitioners of Intuitive Intonation opt for studio teaching, rather than publishing works of their own. In the case of some texts, it is clear that direct contact with the author, or with a practitioner well-versed in the author's approach, is integral to the fullest application of the method.

Violist André Roy, author of *String Quartet Technique* (2014), describes good string quartet intonation as 'based on a careful, indissoluble blending of each of the four independent voices', and suggests that 'it is therefore essential to take into account three factors when working on intonation: the pitch…, dynamics, and the timbre of each instrument' (Roy, 2014: 5). Roy offers the comment that 'it is more important to consider the relationship of all the notes in a chord than the absolute pitch of a single note' (Roy, 2014: 5).

Roy's book is score-based, with a brief introductory text, presenting exercises consisting of scale sections and arpeggios that build harmony through canonic entrances among the players. Violinist Aaron Schwebel, concertmaster of the Canadian National Ballet Orchestra and a former student of Roy, explains:

> The subject of relativity was prevalent in our coachings. [Roy] was looking for the chord to *ring*. For example, the inevitability of open strings would make it necessary for us to consider a given tonality with respect to its inclusion of those open strings. Something that helped us was that [Roy] encouraged us to tune our instruments with *tight* 5ths—this meant the strings were more sympathetic, the cello C and the violin E sounding closer to a pure third.
> (A. Schwebel, personal correspondence, September 2017)

Schwebel here describes a method of tuning the instruments in fifths that are narrower than natural Pythagorean fifths, in order to bring the cello's low C and violin's high E closer to a Just third (Figure 4.3.1). This strategy is favoured by many ensembles as a way of grounding the collective intonation, as it removes the dissonant Pythagorean third and therefore theoretically makes use of open strings less problematic in harmonic contexts.

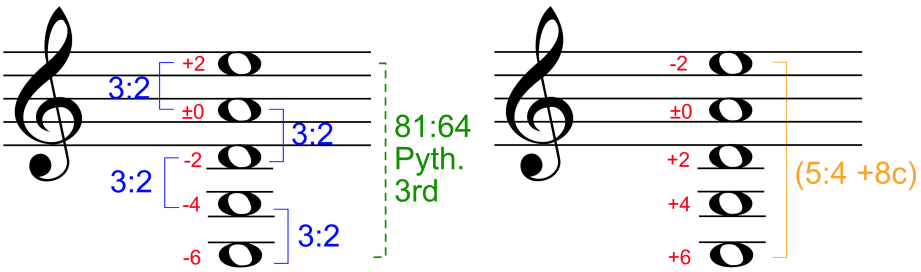


Figure 4.3.1 *An example of the tuning strategy described by Schwebel: each fifth tuned 2 cents narrow of 12-EDO. The resulting third between the lowest and highest pitches splits the difference between the consonant Just third (5:4) and more dissonant Pythagorean third (81:64). This example is based on a similar method that I employed during my tenure with the Bozzini Quartet.*

As a pedagogue, Roy appears to encourage an essentially relational approach to intonation, characterised through simple and pragmatic language. Schwebel relates:

> We never used specific terminology to discuss intonation in our coachings; we were encouraged to use our ears and listen to ourselves as well as the whole group. In order for a chord to ring in a homogenous way, all four parts have to be complementary in their placement. When the chord is *in tune* you can hear other notes in the harmonic series. The goal is optimal resonance—it sounds good. It sounds like there is a mathematical perfection achieved. […] We focused on intonation, but not so much that that we forgot how to be musicians. [...] Our intonation must be slightly flexible. I'm at the point where it's all instinct now. It's important to listen and keep your ears open. When I'm tuning something against someone else, I'm guided by instinct. (Schwebel, 2017)

The Intuitive Intonation paradigm contains distinctive practices which exhibit various, and sometimes contradictory, methods and values. In some cases, words such as *good/bad*, *right/wrong*, *accurate/faulty* suggest a prescriptive approach to intonation not unlike the Projected Fret paradigm. Equally, discussion of *adjustment*, *relationship*, *vibrations*, and tuning *systems* show clear sympathies with Relational Intonation. Where practitioners within this paradigm specifically differ from other paradigms is in the suggestion that intonation is best appraised through spontaneous, self-referential means. Players are actively discouraged from looking outside their own immediate experience of playing and connecting with other ways of modelling or describing musical pitch.

Like other paradigms, Intuitive Intonation relies on 'good tuning' words such as *right*, *pure*, and *true* to recognise consonant, low-order intonation, and 'bad tuning' words such as *bad*, *false*, and *wrong* to denote other more complex pitch relationships. However, the language displayed in this paradigm contains an additional layer of rhetoric, concerned with *difficulty*. Flesch and Galamian are particular agents of this narrative, at various points discussing tuning practice as a *problem* (Flesch, 1930b: 20) of great magnitude, containing components *impossibility* (Flesch, 1930b: 20), and even calling into question the *safety* (Galamian, 1962/85: 22) of the player.

In light of this narrative, Flesch's comments (1930b: 22) about 'personal responsibility' are particularly revealing of a seemingly contradictory dynamic in which players are expected to operate. On the one hand, the player is asked to privilege their subjective impressions of their own intonation over any other available method of evaluation. On the other, they must contend with the potential that these impressions will be called *wrong.* This position necessitates both an

entirely self-referential methodology in practising and an unconditional acceptance of criticism from any source designated as authoritative. It is language that reinforces a power dynamic that favours the teacher by encouraging the student to learn through emulation, rather than building a wide and supportive knowledge base with the potential to sustain their evolving practice.

Technique suffers a loss of status, as players become motivated to attain what Spatz has called 'fundamentally romantic notion' of true art (Spatz, 2015: 28). While the phenomenon of intonation is idealised as a vehicle for individual expression, the technique of intonation is reduced to 'that which must be transcended in order for true genius to appear' (Spatz, 2015: 28). Epitomising this perspective, American violinist and pedagogue Samuel Applebaum proposes that two kinds of players exist: 'those who are those who are conscientious about virtuosity at the expense of good intonation' and 'those who are meticulous about intonation at the expense of the emotional content of the music' (Applebaum, 1986: 45).

The suggestion that technique stands in opposition to artistic inspiration is reiterated throughout the Intuitive Intonation paradigm. While it is not the object of this research to comment on any potential measurable effects of this line of thinking upon the documented intonation of individual performers, it seems justifiable to argue that an overall detrimental effect can be observed in the evolving *discourse* on intonation technique. Indeed, the attitudes described here seem less problematic for the individual performer (who in the end cannot be reduced to a paradigm), than to the task of communicating practice effectively, within the pedagogical space, and between sympathetic practitioners in the field.

4.4 Connecting Threads

In the paradigms proposed in preceding sections, contrasting perspectives on physicality, pitch perception, and performative expressivity lead to widely differing approaches to intonation technique. Nonetheless, some general tendencies have been observed in the rendering of intonation across centuries of practice—notably an overall transition from various open-chain tunings in the 18th century, to more flexible temperaments that accommodate the greater chromaticism of 20th century harmony (Barbieri, 1991: 85–87).

Equally, broad changes have been observed (Stowell, 1985: 254) in conventions concerning *vibrato.* A player's attitude toward vibrato can significantly impact their approach to intonation—

vibrato creating frequency modulation which reduces the clarity and consistency of proportional pitch relationships (Geringer et al., 2009). Until the early 19th century, there is no evidence that players employed the use of consistent vibrato as a means of adjusting intonation (Stowell, 1985: 254). By the early 20th century, perhaps as a result of the practices of influential pedagogues such as Galamian[20], the technique had entered standard practice. Vibrato-for-intonation has, however, remained a matter of debate. Galamian's own teacher, Leopold Auer, categorically censures the use of consistent vibrato, stating:

> Resorting to the *vibrato* in an ostrich-like endeavour to conceal bad tone production and intonation from oneself and from others not only halts progress in the improvement of one's fault, but is out and out dishonest artistically. (Auer, 1921: 22)

Disagreement of this nature even occurs within the oeuvre of single authors: while Flesch recommends practicing 'without vibrato, and if possible with the aid of the corresponding open string' (1924: 21), violinist Max Rostal, in his preface to Flesch's Scale System, offers the contradictory advice:

> Practising invariably without vibrato, as so many teachers recommend for reasons of intonation, is an outdated method in my opinion. After all, even when vibrato is used, intonation must be accurate. (Rostal in Flesch, 1986)

Rostal, in his insistence that vibrato must not prohibit 'accuracy', marks (albeit unintentionally) the source of this fundamental disagreement on technique—a lack of consensus on the meaning of 'accurate'. Terminology brings great ambiguity to the discussion of string intonation, and instances of borrowing and re-defining language cause frequent confusion between author–practitioners as well as wider paradigms. Tuning systems are a source of particular confusion. For example, Campagnoli discusses 'the Temperament' (see 3.1, p. 68) in reference to the area of intonational compromise between the fingerboard locations of enharmonic sharp and flat pitches (Figure 3.1.8). Over 150 years later, when Galamian (1962: 22) states, 'it is necessary to consider what type of intonation ought to be used: the "tempered" or the "natural"', it is apparent that he is similarly differentiating between keyboard-oriented temperaments (as championed by Spohr) and consonant, low-order tunings (as employed by Joachim).

[20] Within Galamian's general condition of constant vibrato, it is suggested that expressive contour can be achieved though variation in the speed and amplitude of the vibrato. 'White' sound, by which he describes pitch *without* vibrato, is to be used only as an occasional (and intentional) colour in the expressive narrative. (Galamian, 1962: 37)

Sevcik uses the terms ‘tempered’ and ‘normal’ in an altogether different fashion, to denote the intonation of pitches as they relate to adjacent open strings. Christine Heman argues that Sevcik’s application of these terms is in fact specious, stating:

> Sevcik, in his intonation school … has referred to the E in the pure major sixth above an open G string as a “normal stop”, and the same E as a perfect fourth below an open A string (which needs to be played somewhat higher) as a “tempered stop”, which is acoustically and physically incorrect, since the tempered E lies between these two extremes.
> (Heman, 1981: 7)[21]

As such, it remains unclear whether Sevcik’s use of the terms ‘tempered’ and ‘normal’ bear any connection to Galamian’s. Violinist Samuel Applebaum’s attempt to clarify this distinction raises additional confusion, when he writes:

> “Natural” intonation uses the mathematically correct or true scale. It is also referred to as “expressive” intonation. […] When a string player plays with a pianist, the intonation is adjusted to the piano; there is no choice. But when playing with a group of strings, each player tempers the notes slightly to achieve good intonation. (Applebaum, 1986: 46)

Applebaum’s assertion that a group of string players will ‘temper’ their pitches is misleading, as he appears to be pointing to the distinction between keyboard tuning, which would in fact require the player to use a more exaggerated temperament, and string intonation, which can traverse a subtler range of ‘natural’ or *un-tempered* intervals. Similarly, Applebaum’s equation of ‘natural’ and ‘expressive’ intonations actually contradicts the meaning implied by Casals, for whom ‘expressive intonation’ was a form of temperament, or exaggeration of the tendencies of Pythagorean intervals.

Still, perhaps the most ambiguous descriptions come in the form of qualitative adjectives. ‘Good-tuning’ and ‘bad-tuning’ words (Figure 4.4.1) are woven throughout these texts, with common words such as ‘pure’ or ‘true’ describing differing, often *opposing* concepts of pitch space. Roland Barthes’ critique of the adjective as ‘the poorest linguistic category’ (Barthes, 1985: 267) might just as well be a commentary on the language of string intonation.

[21] Original German: Sevcik in seiner Intonationsschule … e in reiner großer Sexte zur leeren G-Saite als “Normalgriff”, das e als reine Quarte zur leeren A-Saite (das ja etwas hörer gespielt warden muß) als “temperierteen” Griff bezeichtnet, was akustich-physikalisch falsch ist, da das temperierte e zweischen diesen beiden Extremen liegt. (Trans. Shoshana Schwebel, August 2016)

‘In tune’	**‘Out of tune’**
• exact	• inexact
• correct	• incorrect
• true (truth)	• false
• accurate	• wrong
• clean	• faulty
• secure	• poor
• precise	• bad
• pure	• sin

Figure 4.4.1 *Qualitative adjectives describing ‘in tune’ and ‘out of tune’*

Despite fundamental differences in priorities and methods, the common goal of achieving improved intonation technique links all these practices. That the advancement of proficiency (in whatever capacity it is recognised) is the primary value among such texts is unsurprising—string playing is a field rife with professional and economic motivations that accompany artistic impulses. The author-practitioners reviewed here are all self-described performers, or pedagogues well-known for producing acclaimed players. With their own reputations invested in the perceived effectiveness of their teachings[22], it is perhaps unsurprising that so many author–practitioners focus on supplying solutions to problems, and rules that promise to guide players to technical certainty, rather than advocating reflective practice and curiosity about the interpretive potentials of intonation.

Jacoby observes a general lack of interest in the detailed mechanisms of technique on the part of naturally ‘gifted’ players, arguing:

> Many of the worlds most acclaimed executants owe more to a combination of innate facility and hard work than they do to the application or even understanding of any really logical system of study—a fact which has often been misinterpreted as evidence that theoretical rationalization of the subject is unnecessary or undesirable.
> (Jacoby, 1985: 2)

[22] For example, upon the death of Ivan Galamian, a tribute article in the New York Times described how the pedagogue’s ‘ego was entirely bound up in the accomplishments of his students’, citing an example from Galamian’s close colleague, the violinist Josef Gingold: ‘I always used to sit with him at concerts, and before one of his students would start to play Mr. G. always held my hand and it was trembling! He was feeling for this boy as if he were concertizing himself.’ (Karp, 1981)

This impression, to which Jacoby attributes an overall 'preference for the didactic rather than the analytic' (Jacoby, 1985: 2) in the discourse of string players, is itself a product of Jacoby's own subjective experience, and not of formalised or methodical research. However, such a supposition does offer one possible explanation for the persistence of texts such as Flesch's and Galamian's as staples of violin pedagogy, nearly a century on from their original publication, while Heman's book, much more thorough in its attentions to the measurable phenomena of tuned pitch, remains untranslated and out of print just thirty years after publication.

4.5 Components of an Embodied Paradigm of Intonation Technique

The paradigms of intonation technique explored in the preceding sections are neither exhaustive, nor fully representative of the practices that emerge from them. They may, however, be helpful in emphasizing certain patterns and commonalities that link the contributions of individuals, forming the broad historical and cultural foundations from which new technique can arise.
These paradigms suggest 1) that no single, standardised technique of string intonation exists, but rather that contrasting techniques and practices develop through professional and pedagogical affiliation, and 2) that nonetheless, across these various approaches, the majority of string players tend (with some exceptions) to identify low-order consonance as being 'in tune'.

As the preceding discussions demonstrate, this correspondence is deeply internalised by players, informing both the matter and discourse of intonation technique. It has worked its way into our language, colouring our characterisations of intonation to the point that in-tune-ness is presumed to be an absolute property, and often left unscrutinised. Two contrasting epistemologies of intonation emerge: one which is idealised in discourse, and another which is observed and reflected upon, having sounded. This tension is apparent in the incongruity between the discussions of intonation technique by string practitioners presented in this chapter and the embodied technique of intonation proposed in Chapter 1.

Readers of Tenney will understand that the region of tolerance of most low-order intervals accommodates some variety in our perception of in-tune-ness. Sabat has suggested that tuneability cannot be construed as a finite property, and that consonance is perceptual and subjective. Following Spatz's epistemplogy of practice, I have argued that perception of and reflection on intonation are components of embodied technique, which, like the manual

components of a player's technique, can be learned, grown, and shared. In-tune-ness, in these contexts, is a reflective negotiation between ways of knowing, played out in practice.

Little of this multimodality is reflected in the preceding discussions of intonation technique by players. Being portrayed as enacted primarily in the hands, secondarily in the mind, and to varying degrees in the ears, intonation technique is offered as a means to the tautological end of playing 'in tune'. With motivations ranging from defining measurable certainties (Projected Frets) to attaining transcendence through intuitive sensibility (Intuitive Intonation), the authors reviewed here devise methods for securing in-tune-ness without a substantial contemplation of *listening*—an undeniably crucial component of any technique of intonation. Even among those practitioners for whom aural technique takes greater priority (Relational Intonation) there is a tendency to try to summarise the inherent variety in perceived intonation through semantic modelling, and then to approach these models with much the same linear intentionality—accommodating difference, to be sure, but fixing it nonetheless.

In contemplating 'new' or 'experimental' practices, a player must clarify how and through what means what is being called 'new' connects to existing practice—connections which are most readily observable in lines of technique which run unbroken beneath shifting conventions of performance and musicality. My own question in this context, then, is on which points can or *must* I retain the methods and values of common practice string playing, and to what extent have I the luxury of starting afresh in building my technique of intonation?

The incongruity repeatedly observed (Kimber, 1992; Richter, 2013; Priester, 2015) in string literature, between detailed elucidation of manual technique and relatively simplistic discussion of aural and other embodied technique (including listening and audiation), suggests which areas of technique might draw supplemental focus in a contemporary practice. As Priester writes:

> The pedagogical literature has been very good about addressing manners of execution which lead to proper intonation. But, the assumption taken in the literature is that the student is correcting poor intonation which has already been discriminated. (Priester, 2015: 6)

Established mechanisms of left-hand fingering need not necessarily be reinvented—standard practice methodologies have been undeniably effective in establishing functional dexterity and relative precision in manual technique. However, the observational and reflective processes through which sounded pitch is perceived and imagined—the nature of the 'judiciousness' with

which frequency must be placed—may benefit from a fleshing out in our techniques of intonation.

The research that comprises the remainder of this thesis will put forward some approaches to the observation of and reflection on intonation, replacing the presumed goal of playing in tune with necessary questions, such as *what will be my tuning practice in this instance?* and *what patterns of technique will enable me to structure that practice?* Primarily, it will re-contextualise audiation—traditionally depicted in terms of linear intentionality (i.e., *think-it-then-do-it*)—as an integrated component in a reflective embodied technique, focusing on *listening* and the *aural imagination*.

Listening

Listening holds an obvious colloquial position in the lexicon of string intonation technique, being categorically associated with 'the ear', which is discussed variously as a gauge of accuracy (Flesch, 1924), a means of satisfaction (Geminiani, 1754), an instrument of measurement (Heman, 1964), and a site of intellect (Sevcik, 1922). As a perceived *act*, in the sense of a non-continuous event that can be done and re-done, listening is tendentially placed in direct linear succession with *sounding* (following enactment of manual technique), as a means of discerning acceptable from unacceptable intonation (Figure 4.5.1).

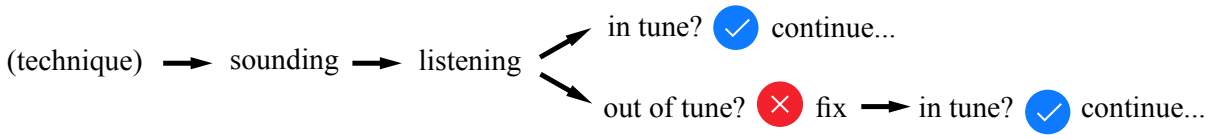


Figure 4.5.1 *Listening as a means of discerning accuracy*

However, as composer Warren Burt notes in his paper on *Ways of Listening* (2009), 'we are often doing more than one kind of listening at one time' (Burt, 2009: 5). Listening can be voluntary or involuntary, 'will-directed' (Burt, 2009: 4) or spontaneous. Sometimes it is necessary to construct 'safe environments' (Burt, 2009: 4) where one type of listening can be set aside in favour of another. In the now seminal *Traité des objets musicaux* (1966), Pierre Schaeffer proposes four

distinct modalities of listening, stemming from four French verbs which can be used to translate the English verb, 'to listen'*: ouïr, comprendre, écouter,* and *entendre*, summarised briefly below.

Ouïr, being the most obscure, describes 'a type of inattentive audition, where sounds pass through the listener unnoticed' (Kane, 2012: 440). *Comprendre*, relating to understanding, implies a mode of listening 'aimed at extracting the message from an utterance or proposition' and extending to 'quasi-linguistic grammars as well, like those of tonal theory' (Kane, 2012: 440). *Écouter* suggests the identification of sonic objects 'on the basis of their distinguishing sonic characteristics' (Schaeffer, 1966: 106), where 'objects presented perceptually are posited as really existing' (Kane, 2012: 440). As Schaeffer writes, 'To listen [*Écouter*] here is to intend [*viser*], across the instant of the sound itself, something other than it' (Kane, 2012: 440)[23].

Écouter thus takes a 'selective, positional and indexical' attitude toward listening, which is 'for the most part, unreflective' (Kane, 2012: 440). Finally, in *entendre,* listening is directed 'toward sounds as such, not to the significations or indices that are associated with sounds' (Kane, 2012: 440). Translated in some contexts as 'hearing'*, entendre* differs from *écouter* (listening), as Brian Kane writes, in that it 'implies an emphasis on the sensory relationship between world and listener, a listening that begins not with the search for meanings but on the basis of the sensory qualities of sounds' (Kane, 2012: 443).

The discriminating ear implied in many of the preceding discussions of intonation technique might take a position somewhere between Schaeffer's *écouter* and *comprendre*, being concerned primarily with discerning what is *signified* by pitch—both in the meanings and values assigned to frequencies or recognisable proportions, and as these are situated within 'quasi-grammatical' contexts, when intonation delineates a particular tonality or harmonic grammar. However, with heavy emphasis on signification, such a listener may find themselves, in the words of philosopher Jean-Luc Nancy, negotiating a tension or balance between *entendre* and *écouter*—'a sense (that one listens to) and a truth (that one understands)' (Nancy, 2007: 2).

[23] Translated from the French: 'Écouter est ici encore viser, à travers le son instantané lui-même, une autre chose que lui ...' (Schaeffer, 1966: 106).

Spatz (2015: 51) recognises a source of this tension in the body, noting 'that epistemic practice involves a continuous and mutually constituting transformation, back and forth, between the two categories of conscious and unconscious knowledge, or what one has (knowledge) and what one is (identity)'. However, they argue that 'the sharp distinction between what one "has" and what one "is" fails to account for the fact that the latter develops directly out of the former' (Spatz, 2015: 53). Nancy might agree, reflecting on the 'shared space of meaning and sound' which he calls 'reference [*renvoi*]' or 'referral' (Nancy, 2007: 7):

> Meaning … is made of a totality of referrals: from a sign to a thing, from a state of things to a quality, from a subject to another subject or to itself, all simultaneously. Sound is also made of referrals: it spreads in space, where it resounds while still resounding "in me".
> (Nancy, 2007: 7–8)

For Nancy, listening is not an action carried out upon a sound (object) by a listener (subject), but rather, in the concept of *renvoi*, connotes a relational space in which 'to listen is to enter that spatiality by which, at the same time, I am penetrated, for it opens up in me as well as around me, and from me as well as toward me' (Nancy, 2007: 14). The player, or for Nancy 'the subject who is listening', is thus also '"subject to listening" in the sense that one can be "subject to" unease, an ailment, or a crisis' (Nancy, 2007: 21). Ultimately, Nancy suggests, they are 'perhaps no subject at all, except as the place of resonance' (Nancy, 2007: 22).

Kane submits that 'Nancy's attention to the difference between *entendre* and *écouter* is ultimately a way of reformulating the question of the subject by encouraging a shift … [toward] a subject that is listening to the infinite *renvoi* of meaning, sound, and self' (Kane, 446.) In this mode of listening 'no reduction or decision between *écouter* and *entendre* [need] be made' (Kane, 446). The player thus neither fully determines what is sounding through listening, nor is their listening wholly subject to what is sounding, but rather the player is the *site* of listening, suggesting that listening is not solely the domain of 'the ear' but a wholly embodied technique in which continuant processes of observation, reflection and enactment coincide. Traditional notions of audiation as a directive for bodily action are shown to be incomplete in the context of this embodied technique.

Recent research in neuroscience has demonstrated that 'the sensory experience of musical patterns is intimately coupled with action', and more specifically that 'musical practice … bind[s] representations of sound and motion, so that finger motions trigger imagined sound, and heard

sound triggers imagined finger motions' (Margulis et al., 2009: 274). Furthermore, it has been shown that '"mental practice" and physical movements share a common neural subspace' (Natraj & Gangully, 2018: 998), and that consequently imagined action can be adapted into the physical domain. Audiation, or activation of the *aural imagination*, might thus be considered a listening practice; in both instances, the same embodied techniques are engaged.

Aural Imagination

Recent practices of experimental music have established precedents for the engagement with 'internalized aural impressions' (Gottschalk, 2016: 123) as listening practices. A primary example is the work of composer Pauline Oliveros, whose *Deep Listening* practice she describes as 'a philosophy and a practice […] that explores the difference between the involuntary nature of hearing and the voluntary selective nature of listening' (Lely & Saunders, 2012: 290). In *Ear Piece* (1998) Oliveros poses questions about listening, which include:

> Are you listening now?
> Can you hear now and also listen to your memory of an old sound?
> If you could hear any sound you want, what would it be?

Although *Ear Piece* was originally conceived to generate source material for a radio *hörspiel,* James Saunders suggests that 'the nature of the activities suggested by the score might vary considerably' (Lely & Saunders, 2012: 293) and could potentially include entirely internalised, unvoiced instantiations. Whether the work is performed 'through a mental realization, or as a written or spoken exercise', Saunders remarks, '[i]t would be "sonic" in the sense that sound and hearing, both active and receptive, are the foci of attention and stimuli of awareness' (Lely & Saunders, 2012: 294).

Sound artist and composer Amnon Wolman takes such foci to a listening public in his *Imaginary Pieces* (1998–), work he describes as 'composing in the mind of the audience' (Lely & Saunders, 2012: 420). His verbal score for *February 26, 2000* begins:

> A new sound, a very nervous, taut and nerve-racking sound. You hear it and almost want to put your finger in your ear to dampen it, but you hold back, reasoning that it will mutate, it will turn into something else, but it doesn't…. Every once in a while the volume seems to have a bearing and it is possible that perhaps it will disappear, but it doesn't…. When you

> (and I) spin our heads it seems to alter only slightly, but then you recognize that it didn't really change. (Wolman in Gottschalk, 2016: 126)

Wolman writes that these works were motivated by a discomfort with his own assumption that

> sound is a literal physical entity, while the other aspect of 'sound', the imaginary one, the one we can recall in our mind without any physical sensation, I treated as a separate entity. (Wolman in Lely & Saunders, 2012: 420)

Composer Jennifer Walshe describes a similar process of aural imagining, which can furnish a sounded vocal performance:

> The performer, for example, might be required to imagine the inside of their body as the interior of a mountain full of mines, feel the blood moving through their veins as tiny carts carrying diamonds to and fro through a tunnel system, and then tip these tiny imaginary diamonds into their lungs to prepare for creating a sound. (Walshe in Saunders, 2009: 344)

These 'unreal sounds' (Priest, 2013: 208), are for Walshe 'at times imaginary, sounds which function as conceptual descriptions' (Walshe in Saunders, 2009: 344). Nonetheless, the process of imagining sound can have a profound effect on the performer, as Walshe explains:

> my intention is that all this preparation and delicate attention means that when the performer emits a vocal sound which atomizes the diamond dust, creating a crystalline mist through the air, there's a quality to the sound which comes from these imaginings. (Walshe in Saunders, 2009: 344)

In each of these examples descriptive, verbal notation has been used as a means of inciting the aural imagination. Similar processes have been proposed with particular attention to pitch. Oliveros' *The Tuning Meditation* (1971) from *Four Meditations for Orchestra* (1996) instructs:

> Begin by playing a pitch that you hear in your imagination. After contributing your pitch, listen for another player's pitch and tune in unison to the pitch as exactly as possible. Listen again and play a pitch that no one else is playing. The duration of pitches is determined by the duration of a comfortable breath or bow. (Oliveros, 1996)

Where Oliveros invites players to oscillate between matching and differentiating *stated* reference pitches, interdisciplinary artist Ada Grass invokes *imagined* reference pitches in order to provoke another experience of listening to intonation. *Cardinal* (2013) includes a page of found four-part chorale music, which Grass assigns to any four sustaining instruments. Players are asked to

progress through their individual parts loosely in unison, while tuning each pitch according to various imagined harmonic contexts, which are suggested in the performance instructions. The result is an uncanny harmony, indeterminate in sounding but, for the player, rigorously structured in its technique of intonation. To instantiate this score, players must audiate harmonic contexts, embodying not only the pitches they will sound but also the contextual influences of imagined pitches which will never sound. Grass remarks:

> Imagine a historical symphonic mash-up—the trumpet from Germany in 1903, the cellos from Britain in 1960, the tuba from America in the 1990s, the percussion from modern-day Australia. All playing together, in their own pitch, at their own tempo… it would be a bewildering sound. Each musician should perform their part, moving from setting to setting. First, listening within their imagination, then when they're ready, listening back out. Listening in, listening out. (A. Grass, personal correspondence, 20 June 2016)

As Gottschalk (2016: 127) writes, 'the activated aural imagination may be the ultimate music venue, the site of limitless potential'. Oliveros' account of her Deep Listening practice—coming 'from noticing my listening or listening to my listening and discerning the effects on my body-mind continuum, from listening to others, to art and to life' (quoted in Lely & Saunders, 2012: 290)—generously reinforces and develops the 'reflection' component of intonation technique, proposed in Chapter 1.

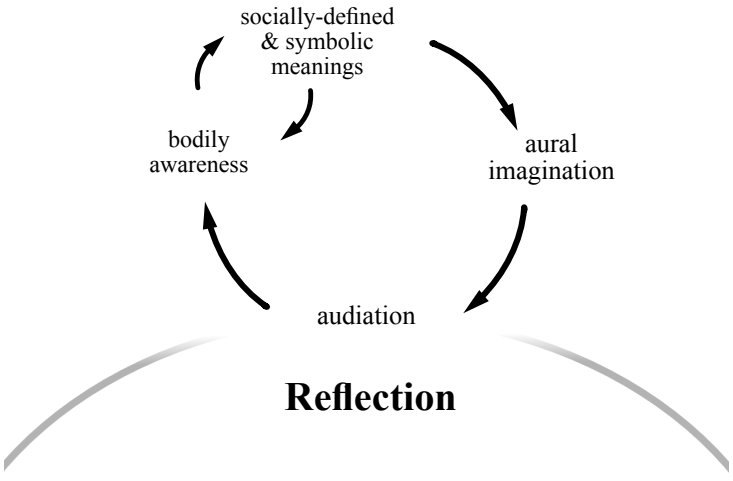


Figure 4.5.2 *Reflection as a component of embodied technique*

An embodied paradigm of intonation technique gathers lived experience (Chapter 1), models of pitch space (Chapter 3) and symbolic representations (Chapter 5), which feed into a reflective embodied practice. This gathering represents the core value throughout my *Instances of Practice*

(Part 3 of this thesis) and will be examined first in practices of violin playing (Chapter 6), and second in communicating this knowledge to other learners (Chapter 7). The reflections on pedagogy that have been explored in this chapter (4) will be carried into critical reflections on my own teaching, which, like playing, I view as a creative practice, structured by the same essential components of technique.

5. (an)Notation

‘Nota bene. Unfolding from within and around these beings we call
our selves, we learn to read the substance of the world:
to make markings stand as notation, we discern and give
symbolic structure to the strands and knots of tangled

temporalities that shape materials, including those
that are evidence of our own corporeal existence…’
(Sally-Jane Norman, 2016b)

In previous chapters, a string player’s embodied knowledge of pitch space, or technique of intonation, has been argued to structure practices of intonation and/or microtonality. This chapter discusses the presence of notation in embodied practice, providing context and critical reflection on the use of annotated scores in the following chapters.

For players such as myself, whose practices engage frequently with notated scores composed by others, the presence of these signifiers can convolute our relationships to our own embodied knowledge. Symbolic meanings contained in systems of notation are transformed through embodied practice—a process that in many contexts might be called ‘interpretation’. Yet, in interpreting, our attention may be drawn away from all of our many embodied ways of knowing, and toward a cycle of discourse about the power structures that accompany notation, as vehemently articulated by Sally-Jane Norman in her poetic work, *Object of Notation* (2016):

> When dwelling on systems that employ symbolic codes, we forget
> the skills acquired to let us see these symbols as such...
> […]
>
> Things already subject to change are further metamorphosed,
> sublimated by our efforts to catch and freeze-frame, represent,
> evoke ephemeral phenomena we cannot fathom
> unless we wrench them asunder, as things to contemplate
>
> and make ours by reigning them in, branding them with insignia
> that testify to mastery, capture, mediation, subjugation. (Norman, 2016b)

Norman here points to a commodification of dynamic phenomena, which in turn can equally lock players into obliged behaviours. As Karl Young writes, '[t]he idea of notation implies, if not demands, *performance* [my emphasis]' (Young in Rothenberg and Clay, 2000). Scores are sites of performance (Allsopp, 2004); maps (Ingold, 2007); sets of instructions (Kennaway, 2010); prescriptions (Thomas in Saunders, 2009); correspondences, communications, messages in bottles, confidential letters to friends (Beuger and Vriezen, 2011); propositions, transmissions (Nickel, 2015); offers, obligations, provocations (Fox, 2014a). Characterisations like these, supplied by practitioners from various musical disciplines, suggest divergent philosophies of music making, yet approach the reading of notation as being directed toward sense-making of a specifically semiotic variety.

Meanwhile, Norman reminds us, notation can also be seen as an 'abstract tool [that] marks its distance from the embodied musician, expressing movements indirectly through its encoded instructions' (Norman 2016a). In re-attuning to our embodied impressions, the temptation may arise to dismiss notation, as Rob Casey adeptly summarises, as '[an obstacle] to pure sensorial engagement with sound (Voegelin, 2010), or as the site of arrogant musical exceptionalism (Kim-Cohen, 2009)' (Casey, 2015: 160). Perhaps notations are, as one practitioner colleague recently provoked in conversation, simply the 'corpses' of practice.

Nonetheless, the infrastructure of my practice is infused daily with the inscriptions of others, and the pursuit of sustainable practice compels players of notated music to take a more generous view of notation. Norman's characterisation of notation as 'indirect' expression creates space for players to re-engage with notation as material that feeds into practices defined by embodied experience. Just as reading and writing have been argued to be rooted in a unified epistemic gesture (Allsopp, 2004; Ingold, 2007), a string player's process of audiation—a wholly embodied imagining of sound—can too incorporate symbolic forms (as outlined in Chapter 1). To summon Ingold's succinct aphorism, 'If writing speaks, then to read is to listen' (Ingold, 2007: 14).

Questions concerning the ontological status of music notation lie outside the remit of this research, having been addressed extensively by Goehr (1992), Kim-Cohen (2009), Voegelin (2010), and Casey (2015), to name a few. The focus in this research context is to question what role notation will play in any given practice. This chapter is therefore primarily concerned with ways that pitch notation may be *used* in practices of string intonation and microtonality.

Potential Categories of Pitch Notation

Most systems of music notation have the capacity to signify pitch, at least to some degree. Where certain qualities or behaviours of pitch are foregrounded in a given musical context, as might be argued is the case in James Tenney's string quartet *Arbor Vitae* (Figure 5.4), various approaches may be taken to reflect these priorities in notation. Some such common approaches are suggested below. The following is by no means presented as an exhaustive survey of pitch notation—contributions of this nature are already numerous, and tend to categorise notation systems by various criteria, which include: notation specific to instrument family (Gould, 2011), perceived determinacy vs indeterminacy (Stone, 1980), perceived prescriptiveness vs. descriptiveness (Howat in Rink, 1995; Kanno, 2007), and within specified instrument families, function, usage or associated technique (Read, 1990; Strange, 2001). Taking this last category as a guide, and considering only the pitch parameter of notation in the Western classical tradition, the following categories might suggest themselves:

1. Ratio notation. Transposable relational notation used to communicate the proportional relationship between two (Fig 5.1) or more (Fig 5.2) pitches or voices, or the figurative relationships of pitches within a single voice relative to a reference pitch or root (Fig 5.3). Ratio notation can be used as a standalone expression of pitch or, more commonly, in combination with Common Practice Pitch Notation, as in the following three examples.

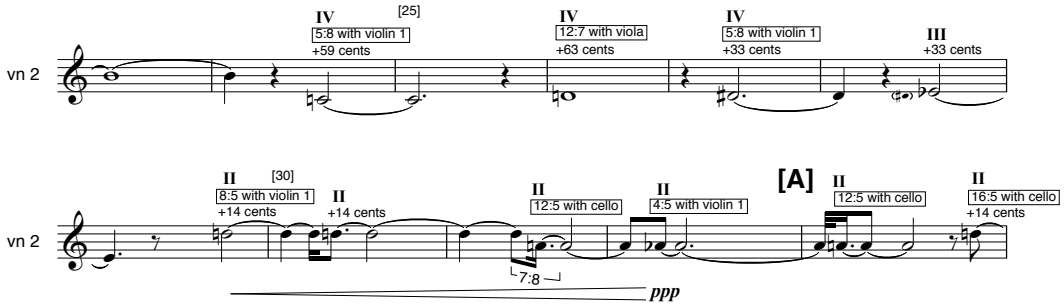


Figure 5.1 *Christopher Fox's* Chambre Privée *for string quartet, second violin part. Ratios guide the player toward tuneable intervals with other voices (e.g., 5:8 with violin 1).*

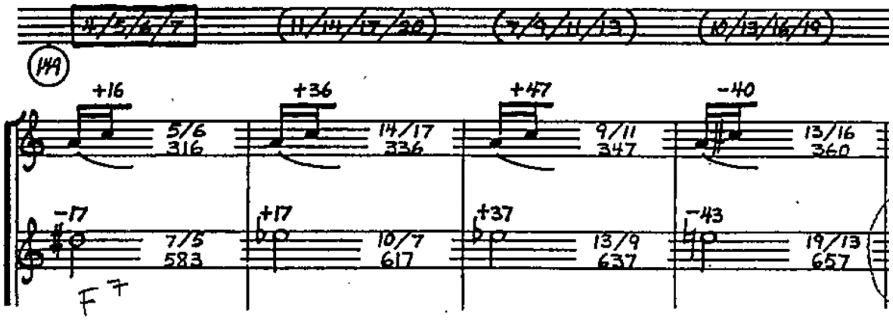


Figure 5.2 *James Tenney's* Koan for String Quartet *with ratios and cent deviations. For each voice, pitch content is expressed in both forms of notation. Running along the top of each score system, composite ratio describes the complete harmony.*

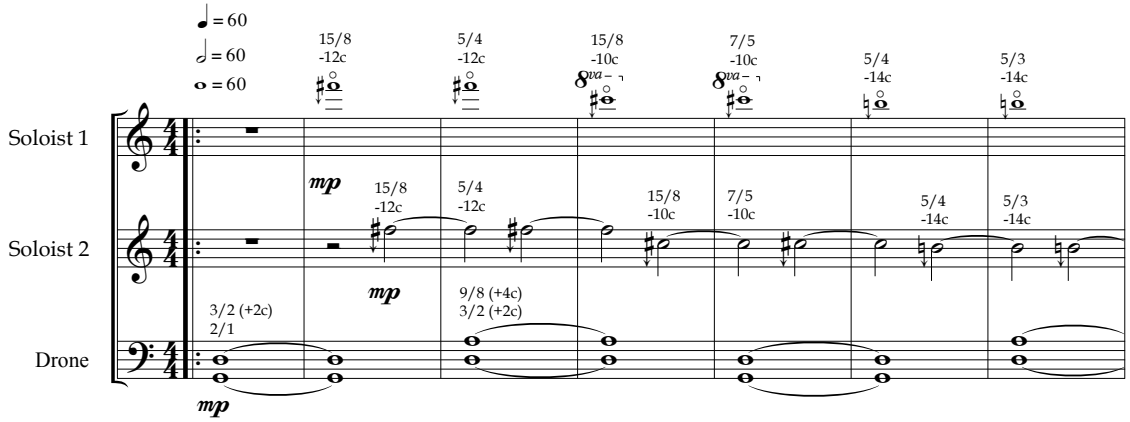


Figure 5.3 *Taylor Brook's* Ptolemy's Observation*, in which a ratio and cent deviation describes the relationship of each pitch over the collective root G (1/1).*

2. Cent notation. Relational incremental alterations based on a scale of 100 units per 12-EDO semitone. As in Figures 5.1, 5.2 and 5.3, cents are frequently used in combination with ratio notation to qualify or specify the role of an individual part or voice within a larger relationship. Cents may be relied upon in performance scores even where ratios may have been used in the original derivation of the pitch material. For example, Tenney's score for his final string quartet, *Arbor Vitae* (2006), employs a cent deviation on each pitch (Fig 5.4), leaving the players to decipher implied relationships, or to approach the realisation of the score through other means.[1]

[1] For example, during my tenure, the Bozzini Quartet used electronic tuners displaying cent deviations in their realisation of this score. This decision was taken because the ratios used to generate the pitch material in this piece

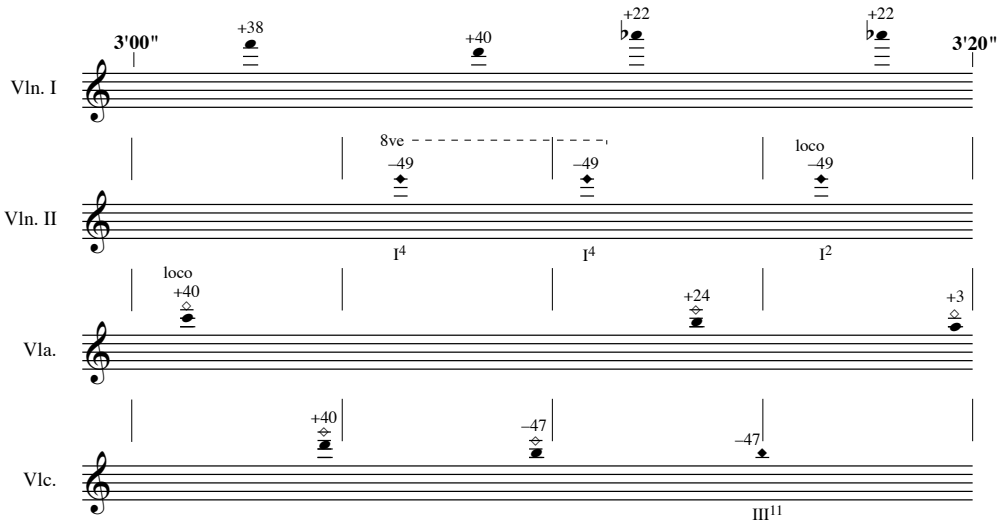


Figure 5.4 *Tenney's* Arbor Vitae *(2006)*

Cent notation can specify a localised intonation behaviour which the player must enact, while at once implying a wider sonority in which the player participates. In a score such as *Arbor Vitae* the fullest potential of the cent notation is arguably realised only when the player is sufficiently familiar with the properties of the structuring tuning system(s) to be able to infer the proportions (ratios) being suggested by cents.[2] Taking as an example the first pitch played by Soloist 2 in Taylor Brook's *Ptolemy's Observation* (Figure 5.3), the player is asked to sound an F# (-12). However, they will also understand that the function of this cent deviation is to reach a just major seventh (15/8) against the Drone. In this instance, the information provided by the ratio may override the cent deviation: in the event that the intonation of the Drone becomes sharpened, Soloist 2 must intone their F# accordingly.

3. Symbolic incremental alterations. Textual or graphic symbols which carry fixed meanings within a given taxonomy. The most commonplace examples of symbolic incremental alterations are the various systems of quarter-, sixth-, eighth-, and twelfth-tone notations which reflect even divisions of the standard 12-EDO, and are commonly represented with

would fall largely into the category Sabat calls 'un-tuneable' (Sabat, 2006), and therefore are not obviously identifiable by ear.

[2] Naturally, where cents are used to represent pitches derived through other, non-harmonic systems (such as some n-EDOs), the proportional implications of cents are less crucial to an informed reading.

modifications of the standard chromatic sharps and flats (as exemplified in Figures 5.5 and 5.6).

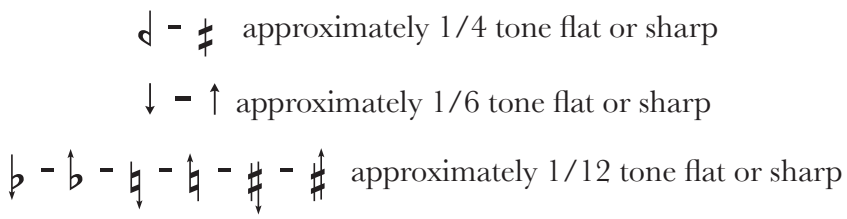
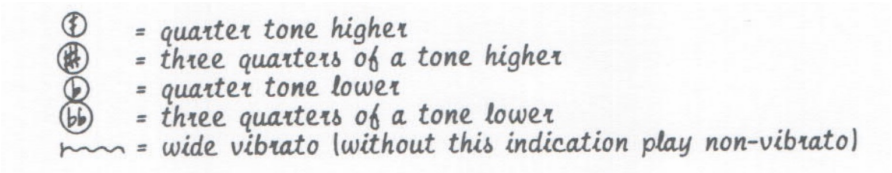


Figure 5.5 *Taylor Brook's quarter, sixth, and twelfth-tone accidental nomenclature*



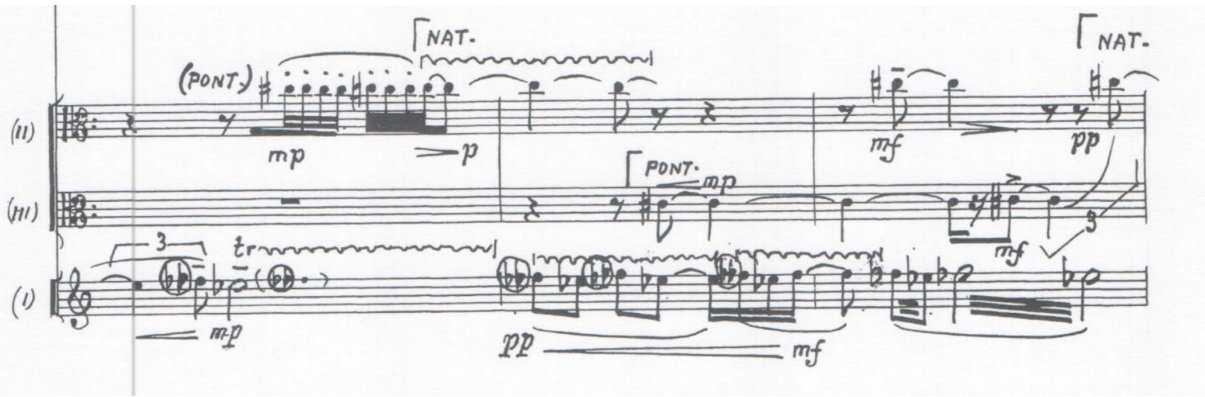


Figure 5.6 *Quarter-tone nomenclature from Scelsi's Fifth String Quartet, a variation of standard extended flat and sharp alterations*

Symbolic notation systems, although they rely upon fixed lexicons, are not inherently tied to closed-chain tuning systems. Sabat, in collaboration with composer Wolfgang von Schweinitz, has contributed The Extended Helmholtz–Ellis JI (HEJI) Pitch Notation (Figure 5.7), a system of symbolic alterations which he calls 'microtonal accidentals' (Sabat & von Schweinitz, 2004). These accidentals, in Sabat's words, 'raise and lower pitches by specified microtones and provide visually distinctive "logos" distinguishing "families" of natural intervals based on the harmonic series' (Sabat & von Schweinitz, 2004: 4). The HEJI Pitch Notation differs from aforementioned EDO-based incremental alterations in that it combines linear and proportional descriptions of intervals (Sabat &

von Schweinitz, 2004: 6) using accidentals to signal harmonic relationships with established roots as well as modifications of 'melodically "nearby" pitches already established' (Sabat & von Schweinitz, 2004: 7).

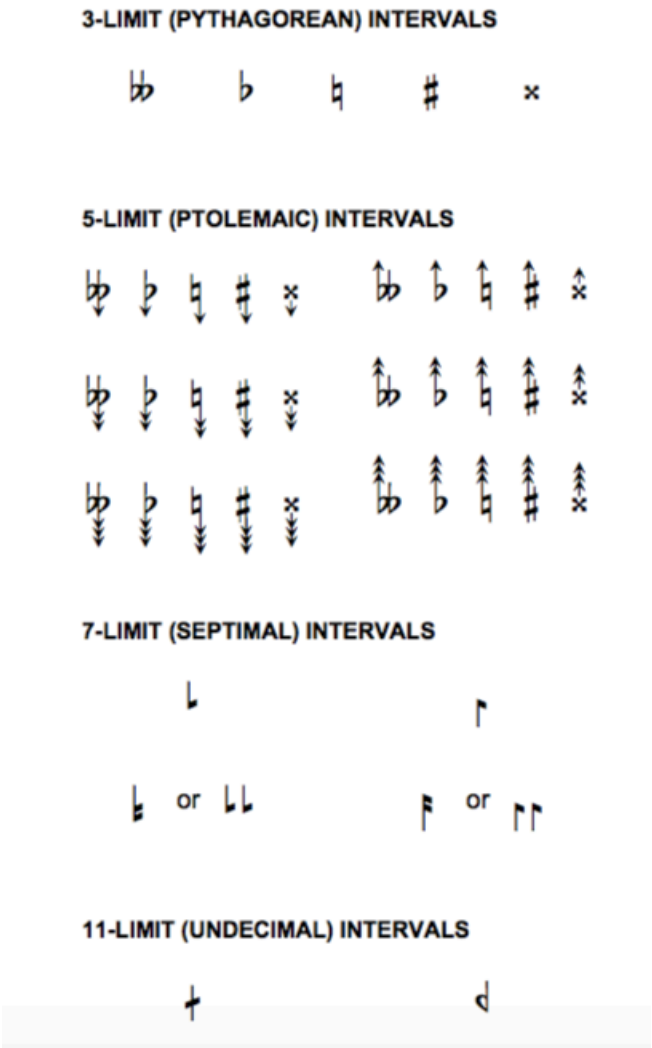


Figure 5.7 *Selection from Sabat & Schweinitz's HEJI Pitch Notation*

4. Trajectories and continua. Notations which describe measured or fluid transitions between two or more specified points on the glissando continuum. Richard Glover's *Seventh Inversions* (2011) invites players to unravel glissando continua between the four nodal points of a seventh chord on A in all its inversions (Figure 5.8). Precise septimal tunings are indicated in cents at the arrival of each inversion, aside from which a fluid trajectory is represented such that the journey between nodes is left for the players to traverse.

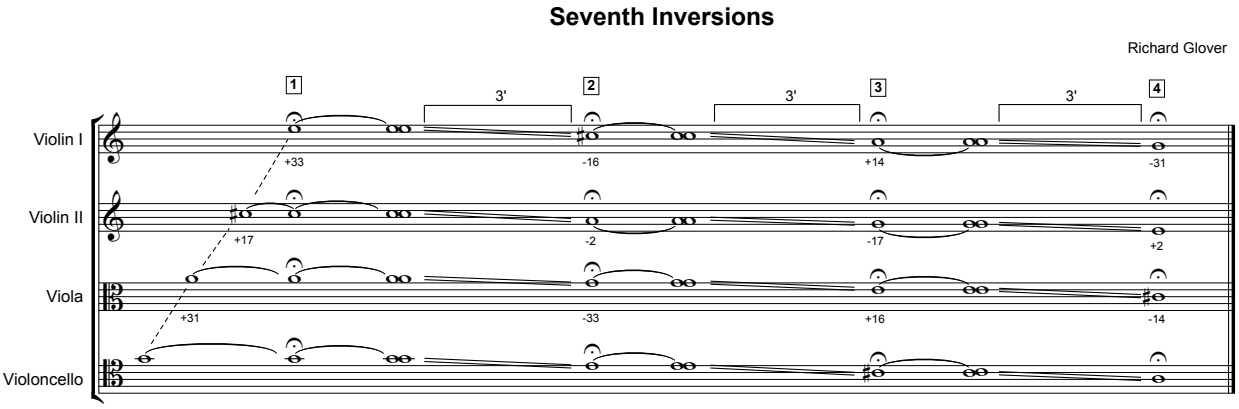


Figure 5.8 *Richard Glover's* Seventh Inversions

Trajectories and continua can be variously notated, creating very different visual impressions which nonetheless elicit much the same technique from players—foregrounding a traversing of the glissando continuum. Tenney's *Koan* (1971) (Figure 5.9) uses a combination of traditional staff notation, graphic glissandi and verbal notation to express a gradually ascending pitch in oscillation against fixed, adjacent open strings.

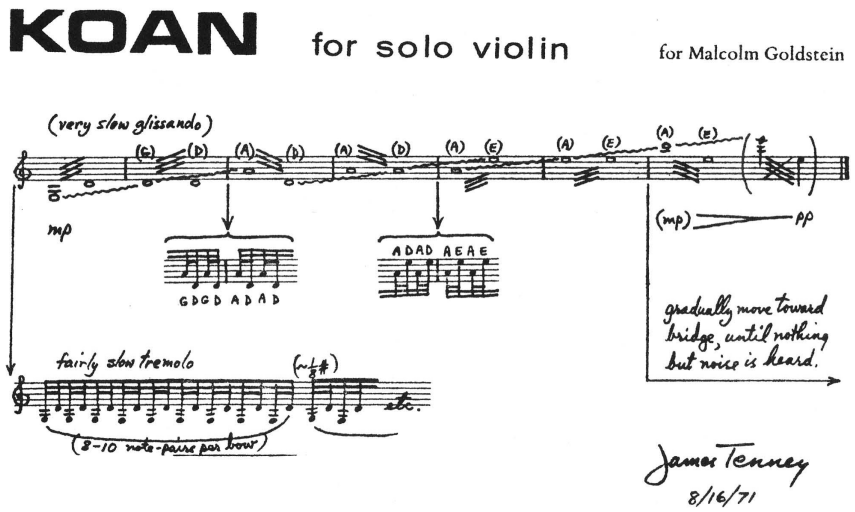


Figure 5.9 *Tenney's* Koan

John Lely's *The Harmonics of Real Strings* (2006; rev. 2013) elicits a similar gradual pitch ascension through entirely verbal notation. An excerpt from the main score text indicates:

> The performer begins on an open string. After some time, and while continuing to bow the string, the performer introduces a light stopping pressure at the point where the string meets the fingerboard. The performer then commences a very slow and consistent movement along the length of the string towards the bridge, maintaining a consistent stopping pressure throughout.
>
> In the later stages of this movement, as the stopped point approaches the bridge, the performer should begin to adjust the contact point of the bow on the string so that the bow is always equidistant between the stopped point and the bridge. When the stopped point and the bow eventually converge on the bridge, the performer ceases bowing. (Lely, 2006/2013)

In Sabat's *Cucumber Serenades* (2009), a rising trajectory in the solo line is measured by absolute degrees of intonation, notated with cents, ratios and the HEJI Pitch Notation (Figure 5.10), of which the composer then writes: 'in hommage to James Tenney: basically a rising glissando is rastered in some way into a sequence of precisely tuned pitches' (Sabat, 2009).

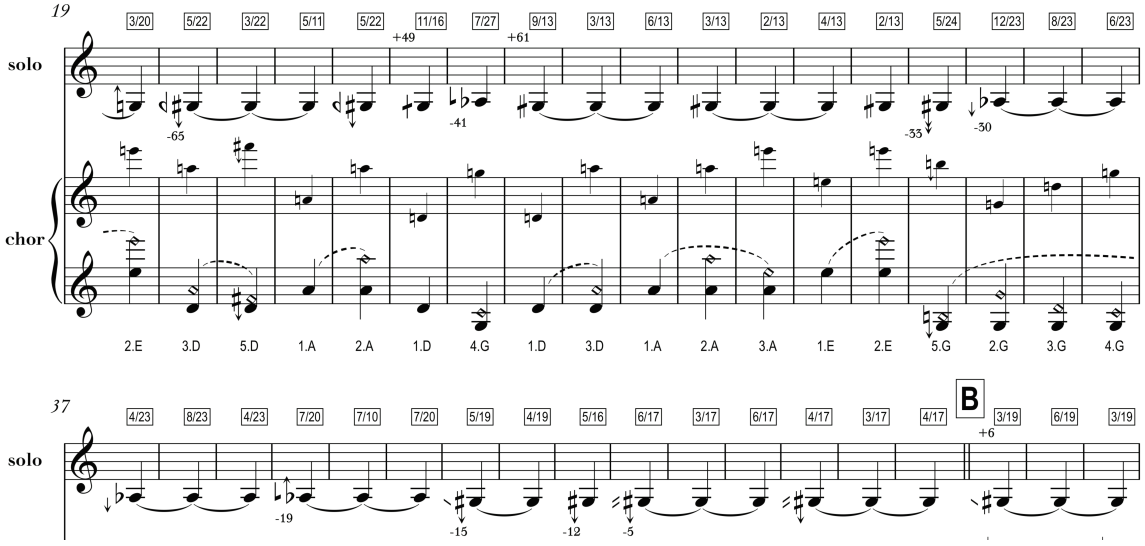


Figure 5.10 *Sabat's* Cucumber Serenades

5. Tablatures and scordaturas. Notation which establishes secondary analogies between notated and sounding pitch, often foregrounding manual execution specific to instrumental affordance. Taylor Brook's *Faith In Numbers* (2010) employs a JI scordatura, and relies upon a dual-system notation of sounding pitch and fingered (transposing) pitch (Figure 5.11). A reading of this notation involves some amount of cross-referencing between the fingered notation (which indicates how each finger placement ideally relates to each tuned string) and the sounding notation (which describes what the player should hear).

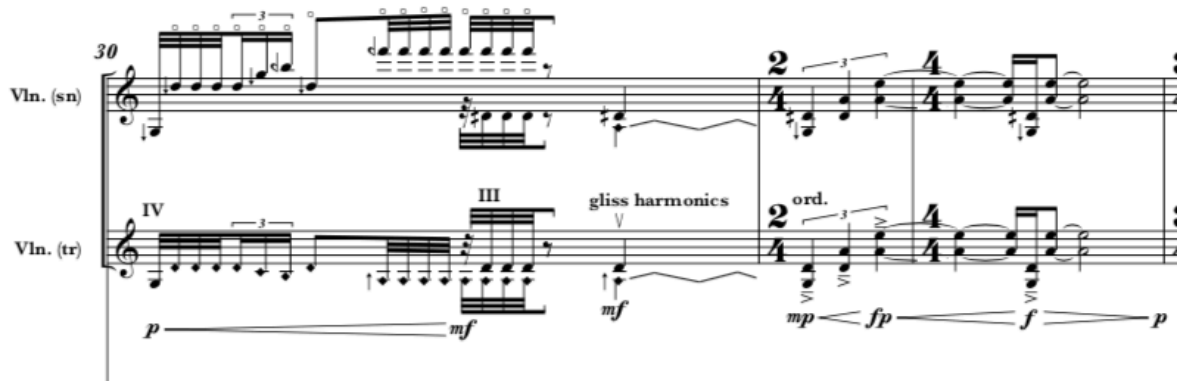


Figure 5.11 *Scordatura (transposing) line (bottom) and sounding line (top) in Taylor Brook's* Faith in Numbers

André Cormier uses a graphic tablature notation to encourage a nuanced exploration of the glissando continuum between two unspecified (but likely 12-EDO) semitones (Figure 5.12). In this notation the gesture traced by the finger is expressed within a limited range of pitches; the actual pitch at any given moment is to some degree indeterminate.

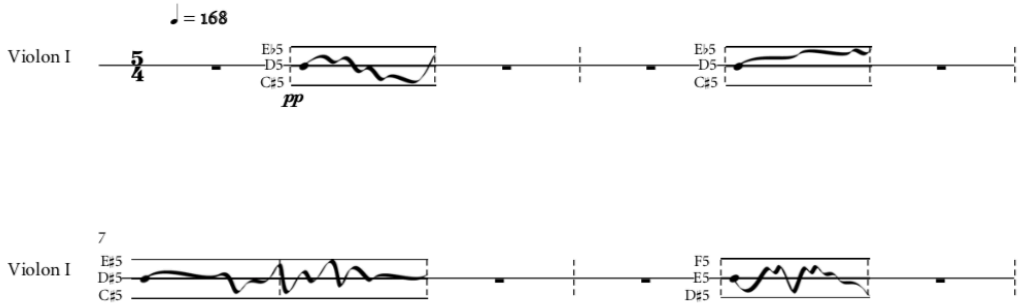


Figure 5.12 *André Cormier's* Petit Quatuor*, Violin 1*

6. Qualitative Description. The use of verbal explanation, either as the sole carrier of content (as in Lely's *The Harmonics of Real Strings*), or to enhance or clarify another system of notation. Isaiah Ceccarelli prefaces the scores for *Bow* (2015) and *Dunstable* (2014–15)—both of which use Common Practice Pitch Notation—with the following:

> Performers should favour tunings without beatings as much as possible, corresponding to low-order ratios. In other words, they tune to other sounding pitches rather than their own instrument and favour harmonic tuning over melodic tuning. No vibrato for string instruments. (Ceccarelli, 2014–15)

7. Implicit pitch behaviour. Arguably present in any system of notation, but perhaps most pertinently observable in Common Practice Pitch Notation, which can effectively imply any other system of notation, as discussed further below.

'How they are directed'

The categorisation of musical notation can reflect a pragmatic desire, shared by many players, to comprehend which aspect(s) of pitch should be prioritised in a reading of a score. Many systems of notation lend themselves to association with particular models of pitch space: ratios, for example, can be suggestive of Just Intonation, whereas symbolic incremental alterations are easily associated with *n*-EDO systems. However, to paraphrase Jennie Gottschalk's discussion of score reading in experimental music practices, categories such as these can often be 'red herrings', as 'the fundamental issue is not what tools are used, but how they are directed' (Gottschalk, 2016: 7).

Exemplifying Gottschalk's argument, Figure 5.13 shows four different versions of a major third (A-C#), which roughly correspond to my above categories 1), 2), 6) and 7):

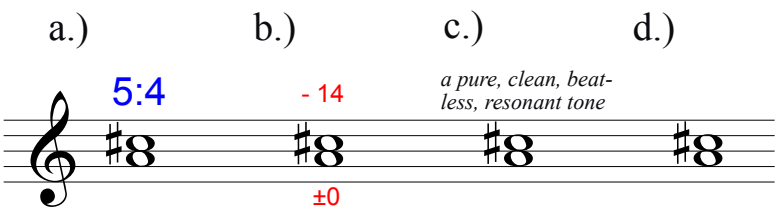


Figure 5.13 *Four descriptions of a Major 3rd*

Each of these ways of notating encourages the player to exercise specific priorities in their enactment of technique. In (a.) the ratio describes the relative size or width of the interval, suggesting that a proportional relationship, and therefore a particular sonority, beating pattern and difference tone, are sought in the player's listening. In (b.) a cent deviation indicates the discrete location of each pitch as it deviates from equal temperament, but for the experienced reader may also implicate the relational proportion of the interval which, in this case, corresponds to the 5/4 ratio. In (c.) descriptive language suggests which qualities of resonance or timbre should be sought in the intonation of the interval, and the player may bring a variety of references or techniques into any realisation. In (d.) intonation is unspecified within the tolerance range of the interval class; the player's tuning choices will be guided by context, and in many cases will rely on literacy with regard to stylistic convention and/or harmonic function.

A significant moment in my evolving technique of intonation came with the discovery that it is entirely possible that these four examples of notation could result in identical renderings: (a.) and (b.) imply identical proportions and frequencies, assuming the same open A-string is taken as the root in both cases. The qualities of 'beat-less-ness' and 'purity' given in (c.) do not categorically indicate the 5/4 third; however, these descriptions are frequently associated with this ratio, as seen in the writings of multiple string practitioners in Chapter 4. Finally, while (d.) might be sounded in multiple intonations, a violinist in search of 'good' intonation may well invoke some of the qualities specified in (c.), and the position of the interval on the violin might further encourage this rendering. Crucially, these renderings would all emerge through common elements of technique.

If these disparate notations can share common technical pathways, *then they must also be interchangeable as material in a string player's practice of intonation*. Divorced of a practice context, sounding in any of these notations is not entirely self-evident. Figure 5.14 describes a likely occurrence in a string ensemble: a cent deviation (+14) describes the location of a fingered pitch to be sounded above another player's open D string (-2), forming a minor third (6/5). It is understood by both players that the aim of these cent notations is to make explicit the means to sounding the proportion of the Just minor third. In the event that pitch of the open D-string in the lower voice should slip several cents during the course of the performance, or if the player of this D decides to sound the pitch in some different manner, the player of the F will have to adjust their pitch accordingly, or else sacrifice the 6/5 proportion. In this instance, the 'right' way to realise the notation may be to play it 'incorrectly'.

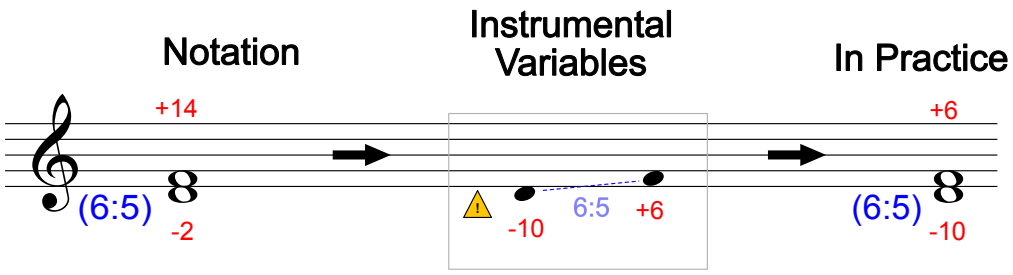


Figure 5.14 *Instrumental variables influence the sounding of notated pitches*

As Norman aptly observes, 'the nature of notation systems … is bound up with what we want to do with them and what we want them to do' (Norman 2016a). Therefore, rather than maps, instruction manuals, transmissions, letters, provocations, or obligations, we might instead find it more appropriate to read pitch notation in much the same way that John Lely proposes to read verbal notation:

> …the [notation] system as a whole may be regarded not as a collection of fixed meanings, but rather as a "structured meaning potential" which is sensitive to context. Any [notated score] may be regarded as an "instantiation" of that system. In terms of the practical realisation of these scores, it therefore seems a natural extension to regard [the score] as itself a structured meaning potential which is sensitive to context. Any realisation of that score may be considered not merely as "one of a limited number of possible outcomes", but rather as an instantiation of the structured meaning potential of the score. (Lely & Saunders, 2012: 74)

Discernible parallels between Lely's notion of realisations as instantiations of the structured meaning potential of scores, and Spatz's notion of practices as instances of structuring embodied technique, lay convincing groundwork for the incorporation (in the very most literal sense) of symbolic representations into the reflective dynamic of intonation technique. Recalling Sabat's suggestion that explicit microtonal notations can 'open up a space' in the mind of a player in which 'a whole range of sounding phenomena' are then potentiated in the reading of a pitch (1.2, p. 44), notations may be approached not as reifications of musical ideas with limited possible outcomes, but as things to be played with, digested and transformed in the embodied imagination.

Annotation and 'the medium of the notebook'

In the following chapter (6) my own realisations of notated scores will be presented and discussed. Broadly, the reflections on technique and practice posited in this and the preceding chapters describe the ways I approach this music. In the tracing of *specific* moments of practice, annotated sections of score will be referenced. In the context of a discussion that began with a rejection of symbolic representation as the reification of an idealised practice, this use of annotations in my discussions of technique may seem regressive. However, my annotations do not describe idealised outcomes, nor are they intended as justifications of decisions made in practice. They serve a specific purpose: to externalise references and models that I draw upon when I exercise embodied technique.

Reflecting on practices of annotation, theatre scholar Timmy de Laet cites 'the medium of the notebook' as evidence that in art practice 'a material externalization of the internal imagination is still highly relevant' (de Laet et al., 2015: 50). Annotated scores (notebooks in another sense) are also marked up, mediated, altered and overwritten, their potential usage described and biased by practice-led inscription. Music cognition scholar Linda T. Kaastra suggests that performance annotations of this nature can be used by players to increase the 'visual salience' of a notation, to effect 'repairs or corrections' to a notation, and/or to demarcate 'performance anchors' which can aid the fluency of reading a notation (Kaastra, 2011: 677). Digital media artist Florian Jenett proposes, furthermore, that 'annotations are a material in itself… [to be used] alongside the original content [and] not as a replacement' (Jenett, 2015: 24). Through annotation, dance theorist Scott deLahunta suggests 'the page becomes less a static site for symbolic depiction and more of an interactive object' (deLahunta, McGregor & Blackwell, 2004: 67).

All these contemplations suggest that annotation can influence the way a player relates to a score. My own annotations function (in Geertz's terms) to *thicken* the notation's capacity to describe pitch meaningfully, and to open up space (Sabat, 2017) in my own reflective technique. A ratio annotation, for example, activates *relationality*—between pitches within the musical context, but also in the fabric of my own technique. By representing internalised references as observable materials, my annotations may then 'help to chart the genesis of a piece by giving a glimpse of its developing poesis' (de Laet, Cassiers & Van Den Dries, 2015: 51).

Part 3. Instances of Practice

6. Instances of Practice I: Audio Recordings, Score Annotations and Commentaries

The portfolio of audio recordings (Appendix A, Tracks 1-6) submitted with this thesis gives evidence of six instances of practice surrounding notated concert music for solo violin or small string ensemble. Each study presented here takes the form of a dialogue between 1) an audio recording and 2) a reflective commentary on the *patterns of intonation technique* being foregrounded, supported by sections of annotated score. The following pieces are discussed:

	Composer	**Title**	**Instrumentation**	**Duration**
6.1	Martin Arnold	*Slip Minuet* (2014)	solo violin	23:42
6.2	Chiyoko Szlavnics	*Freehand Poitras* (2008)	string trio	11:01
6.3	Howard Skempton	*Tendrils* (2006)	string quartet	19:24
6.4	James Weeks	*Windfell* (2017)	solo violin	59:42
6.5	John Cage	*Four* (1989)	string quartet	30:00
6.6	Scott Mc Laughlin	*The endless mobility of listening* (2015)	violin with live electronics	72:00

Throughout the text, time indexes formatted in square brackets—i.e., [xx:xx]—indicate reference points on the recordings, corresponding to examples given in the annotated score examples.

Patterns of Intonation Technique

The six pieces listed above have been selected because they afford discussion of specific patterns of intonation technique, which are grouped as follows:

A) X/Y

   Where local pitch relationships are foregrounded, and technique is directed toward recognising and sounding localised simultaneities with particular relational properties.

B) If, Then

   Where predictive and/or modulatory strategies are foregrounded, and technique is directed toward larger-scale tuning schemas.

C) Indeterminate Pitch Spaces

   Where the occurrence of simultaneities is not predetermined, and technique is directed toward the negotiation of contingency and/or emergent configurations.

Each of these patterns is reflected upon in two contexts: first, where intonation is *implicit* in the notation (i.e., where Common Practice Pitch Notation is used), and second, where intonation is more *explicitly* described by the notation (i.e., where some manner of microtonal notation is used).

As touched upon in the introduction to this thesis, these six pieces might all be regarded as belonging within an 'experimental music' idiom—which for me means simply that they invite a particular focus on, and attention to, sound. They share certain similarities, with perhaps the most obvious among these being a degree of surface simplicity which, through active and attentive listening, reveals degrees of complexity that deepen with an evolving practice.

The focus of the commentaries here is on the patterns of intonation technique which define each practice. Discussion of other aspects of performance practice (e.g., phrasing, gesture, etc.) is very limited. The suitability of each of my renderings is certainly offered up for debate and is discussed in each case study respectively. However, the contribution being made here is in the discussion of technique, not of interpretation. Disparate appraisals of choices made or outcomes rendered in these particular recordings are welcome, but do not undermine the focal position of this research that 1) the patterns of technique being discussed can be directed toward any number of potential practices, and 2) that given renditions (such as the six submitted here) reflect instantiations of technique, which are necessarily 'incomplete' (Spatz, 2015: 63), and from which I, having continued to practise, will inevitably have moved on at the time of their eventual listening.

For these reasons, as well as aspects of aural technique discussed below, methods of measuring moments of intonation practice (ie. spectrographic analyses, electronic tuners, etc.) have not been

used. While such quantitative work would be possible, and could certainly provide avenues for future research, attempts to reify embodied knowledge in quantitative terms would here undermine the essential question being explored: the unpacking of a relational epistemology of musical pitch via intonation technique. In this study, reflections on technique, rather than its localised outcomes, advance its own potential future application, as will be shown in this chapter.

Where each piece sits within the project

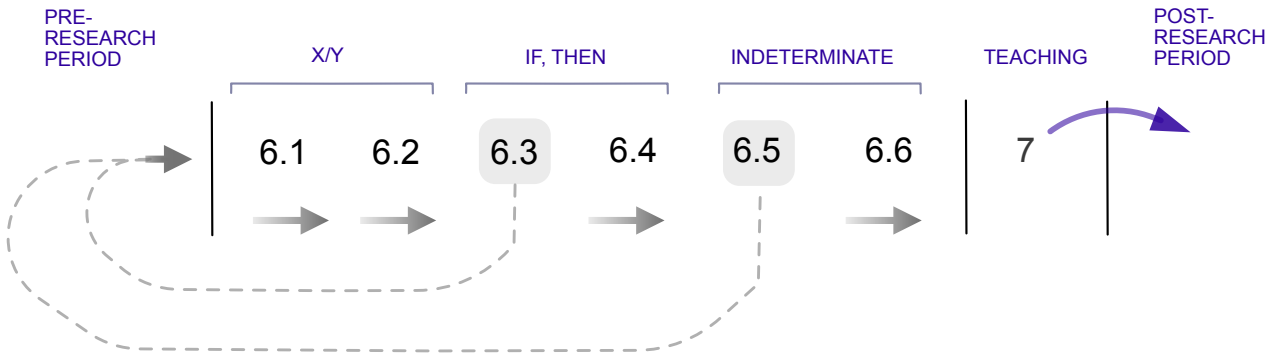


Figure 6.0.1 *Where each piece sits within the project*

Sections 6.1 (Arnold), 6.2 (Szlavnics), 6.4 (Weeks) and 6.6 (Mc Laughlin) discuss my practice of compositions for solo violin or small chamber ensemble, which were recorded during the period of this research. These sections therefore function rather conventionally as case studies of documented practice. The three solo violin pieces (Arnold, Weeks, Mc Laughlin) were original commissions.

Sections 6.3 (Skempton) and 6.5 (Cage) concern compositions for string quartet, which were recorded during my tenure with the Bozzini Quartet, prior to the start of this research. It was important to me to include a discussion of these two pieces because they were crucial 'entry points' in my practice that resulted in the eventual pursuance of this research, and additionally because they acutely illustrate certain patterns of intonation technique which are then expanded upon in my discussion of two recent solo works (Weeks and Mc Laughlin). My discussion of each quartet in this research context is therefore less a case study of documented practice, and more directed toward the analysis of particular challenges and affordances which were revealed through my initial practice of these works, and in which potential future practices might be

situated. The recordings (Appendix A, Tracks 3 and 5) are submitted as reference materials (not as portfolio submissions); however, the accompanying score annotations and critical reflections represent original research.

The reflection upon nascent practices—begun prior to the research period and developed during its course—is a necessary component of this research in that it contextualises the initial motivations which led me to the project, and demonstrates how the research, having been carried out, now informs and enriches my perception of past practices. Furthermore, on a practical note, the development of technique as it is understood in this thesis does *often*, but does not *necessarily*, involve the immediate practice of an instrument. The activation of the aural imagination, and the development of cognitive representations that contribute to the reflective dynamic, can also contribute to the maturation of technique, and therefore could be considered as practices in their own right.

My projected realisations, explored in Sections 6.3 and 6.5 through annotated scores, therefore may be read both as theoretical analyses of musical material, which describe a systematic application of some of the patterns of technique explored throughout this chapter, and also as descriptions of potential practice—of pitch relationships that I can audiate and embody, and which may indeed be called upon in some future instance of practice. Drawing upon these discussions, Chapter 7 will then address how such technique can be communicated effectively in the pedagogical space, presenting an original teaching resource (Appendices B and C) alongside critical reflections on teaching as a creative practice.

6.1 Martin Arnold: *Slip Minuet* (2014)

Martin Arnold composed *Slip Minuet* for me in 2014 as a commission with support from the Canada Council for the Arts. This portfolio submission (Appendix A, Track 1) was recorded by Simon Reynell at Midhopestones (UK) in May 2016, and released on the Another Timbre label (at106 *Martin Arnold: The Spit Veleta*) in May 2017. The piece consists of two contrasting sections—the first bowed and the second plucked—the first of which will be discussed here with respect to patterns of intonation technique relevant to the sounding of tuneable intervals containing open-string drones, the identification of intervals by way of their *difference tones*, and the *repeatability* of Just intervals.

What isn't in the score

Common Practice Pitch Notation is used throughout *Slip Minuet*, as is consistent with Arnold's practice of composing for small chamber ensembles and solo instruments. Reflecting on this choice, Arnold comments:

> In general, my take on notation is to use the most common praxis… I want the basic [notation] to be *very* familiar, and then I just *don't* include a lot of stuff in the score. To me it's like an offering that then the musician brings in their musicianship to shape. To me the easiest way to do that, in terms of keeping that process open, is to have [the score] be as normative as possible. (M. Arnold, personal communication, 4 August 2018)[1]

In keeping with Arnold's sentiments on openness and personal musicianship, and owing to my long working relationship with him, I felt license to develop a Just Intonation practice in this work, even though one is not explicitly stated in the text. I was motivated from the outset to experiment with JI in reading this score because the musical material (pitch material, register, tempo, performance instructions) affords tuneable intervals with particular clarity.

The entirety of the substantial first section of *Slip Minuet* consists of close-position dyads within the range of a fifth, in which the upper pitch is always an open string. This aspect of the score provides a crucial constraint which informs how I approach the material. Arnold instructs the player to use 'very little vibrato; but use occasionally as an ornament' and to 'use open strings whenever possible' (Fig. 6.1.1). These conditions, and the material itself, create ideal conditions for the sounding and hearing of low-order ratios on the violin: tonal homogeneity, a limited harmonic space, and fixed reference pitches, all of which enable clearly audible difference tones[2].

[1] All comments from Arnold cited in this section are taken from a Skype interview, conducted on 4 August 2018.
[2] As cited in Chapter 1: *Difference tones* are frequencies resulting from the difference between the frequencies of two or more primary tones. They are a subcategory of the larger family of *combination tones*, 'the product of nonlinear, acoustic transmission systems' (Lohri, 2010: 97). A second subcategory, *summation tones*, are frequencies equal to the sum of the frequencies of two or more primary tones (Lohri, 2010: 97).

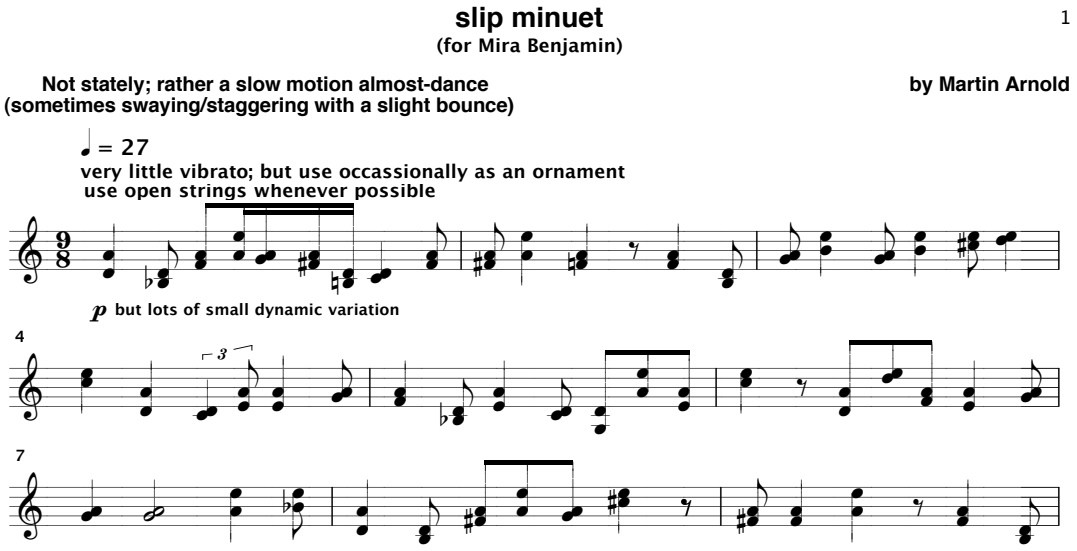


Figure 6.1.1 *Martin Arnold, Slip Minuet, mm. 1–9*

Difference Tones and Repeatability

The recognition of difference tones is fundamental to my practice of *Slip Minuet*. I note here that whilst difference tones are commonly considered to be an exclusively *intra-aural* phenomenon (i.e., a psychoacoustic occurrence not measurable as vibrations in the air), research into *extra-aural* combination tones in violins has suggested that observable difference (and summation) tones result from a combination of psychoacoustic and acoustic mechanisms (Lohri et al., 2010). Violins appear to afford particularly strong extra-aural combination tones, making them well-suited to the methods being developed here.

As Sabat and Hayward (2006: 3) suggest, 'the process of tuning precisely [can be] accomplished by listening to the periodicity of the composite sound and by paying attention to combination tones and beats'. The close-position intervals in the first section of *Slip Minuet* produce clearly audible difference tones, which are an effective means of achieving relatively precise intonation with consistency across multiple repetitions. LaMonte Young, in his notes for *The Well-Tuned Piano*, reflects on this *repeatability* of Just intervals, writing:

> Since intervals from the system of rational numbers are the only intervals that can be repeatedly tuned *exactly*, they are the only intervals that have the potential to sound *exactly* the same on repeated hearing. (in Lely & Saunders, 2012: 437)

Recalling Arlander's proposition (see p. 50) that the sustained repetition of material might be *speculative* in that it creates the potential for alternatives to occur, I was motivated to explore the thresholds of repeatability in Just intervals throughout *Slip Minuet*. This began with identifying low-order ratios that correspond to each recurring interval, as positioned on the violin, and ascertaining resultant difference tones[3]. Many of these intervals—for example, fifths, fourths, major and minor thirds—imply obvious tuneable ratios (Fig. 6.1.2).

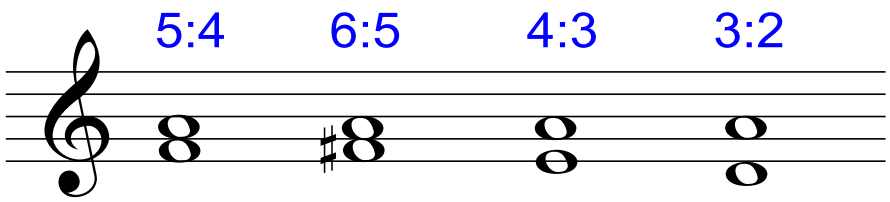


Figure 6.1.2 *Low-order intervals below the open A-string*

For other intervals, multiple low-order renderings were available. For example, both the 9/8 and the 10/9 ratio are tuneable and sit comfortably within the region of tolerance of the major second; in the case of tri-tones, several tuneable ratios including 7/5 and 10/7 were possible. Figure 6.1.3 gives examples of these intervals from measures 1 [0:00] and 7 [1:13] respectively, illustrating how each tuning results in a distinctive difference tone:

[3] I familiarised myself with these relationships using a bespoke difference tone simulator, coded in MaxMSP by composer John Lely.

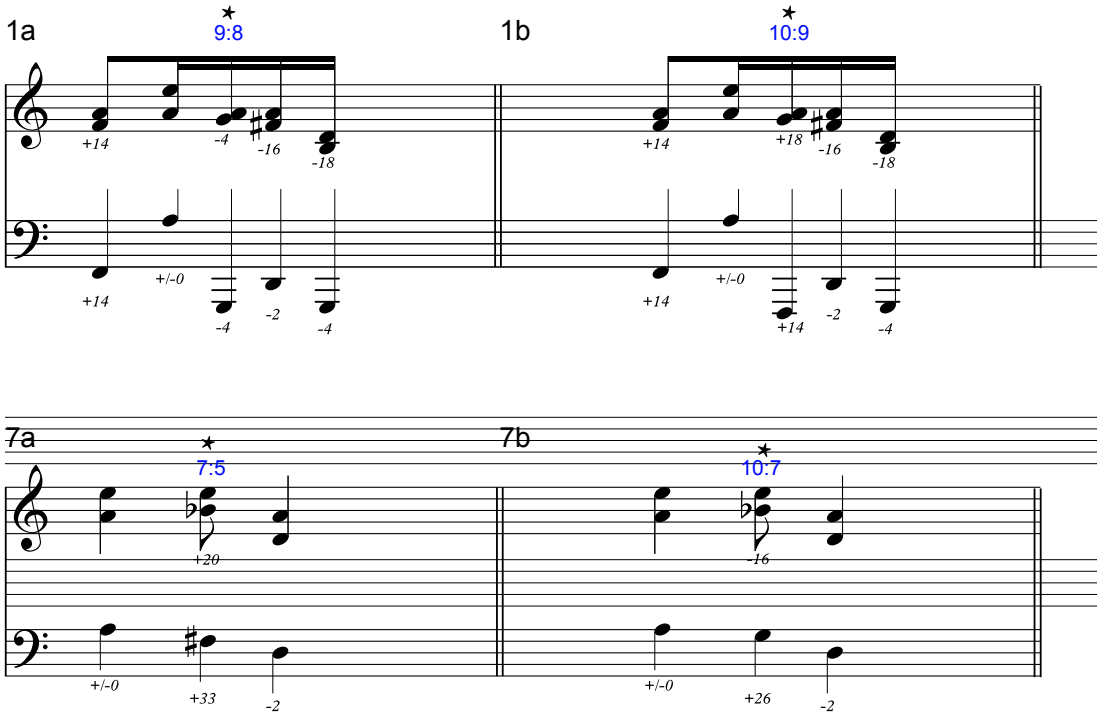


Figure 6.1.3 *Optional tunings of: a Major second (9/8 and 10/9); a tri-tone (7/5 and 10/7)*

As Tartini is reported to have observed, difference tones can act 'like a bass giving the interval a third dimension, a subtle harmonic context' (Lohri, 2010: 96). By placing ambiguous intervals in context and imagining the entire resultant difference tone line as a third voice in the harmony—in essence tuning the material as *three-part harmony* (Figure 6.1.4)—I arrived at the decision to tune the Major second in m. 1 (as well as all subsequent iterations of this interval) as the ratio 9/8, at the augmented fourth in m. 7 (as well as all subsequent iterations of this interval) as the ratio 7/5, for the following reasons: In 1a) the 9/8 second contributes a difference tone G (-4) which mirrors and reinforces the surrounding difference tone line (A +/- 0; D -2; G -4; all of which match open string tunings). By contrast, the 10/9 second in 1b) produces a lower difference tone (F +14) which was (to my ears) less homogeneous within the overall sonority of the implied bass line. My preference at the time of the recording was for the former, so I chose the 9/8 second for this interval. By a similar process, I selected the 7/5 tri-tone because I enjoyed the triadic quality that its difference tone (F# +33) creates in the harmonic texture (Figure 6.1.3, example 7a).

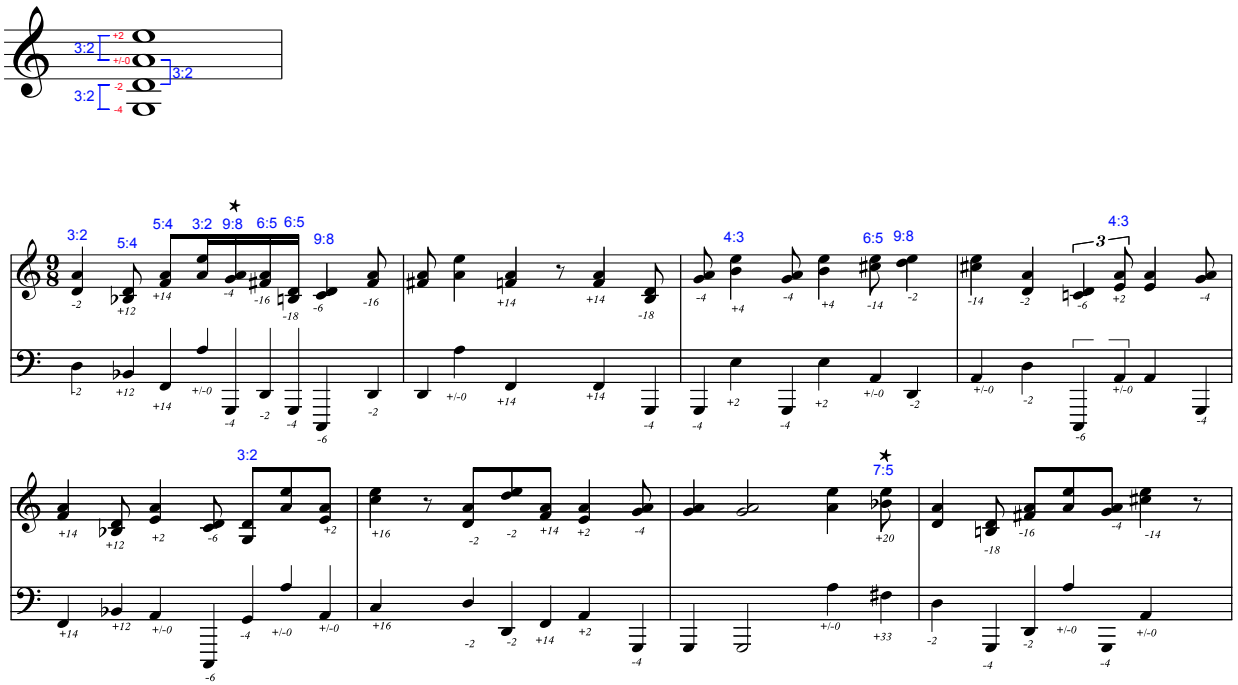


Figure 6.1.4 *An imagined third voice: difference tone line*

Messiness and Presence

Might this practice of intonation, then, be better termed a practice of *microtonality*? The recognition of ratios by way of their difference tones, whilst motivated by experimental affinities with musicians such as Tenney and Sabat, nonetheless relies upon a pattern of intonation technique consistently employed by string players since Tartini's pioneering research, as exemplified in the contributions of Baillot and Heman (Chapter 4). This consistency is not lost on Arnold, who comments, 'My scores look like modern *urtext* baroque scores: one dynamic, no expression markings.' That I became aware of these historical methodologies only through research in support of my own experimental practice reflects the enduring relevance and applicability of this technique which arises from the material affordances of the instrument.

Naturally, the principle of exact repetition does not result in literal repetition in my hands and on the instrument. In the active seeking of intonational precision, I am ever more aware of the *messiness* that characterises this practice. For example, in m. 39 the minor third (B-D) sounds twice, and in both cases I imagined the interval as the ratio 6/5 (D -2/B -18). In listening back to my recording [6:26] I have the impression that the first third sounds slightly wider (i.e., the B is slightly lower) than the second.

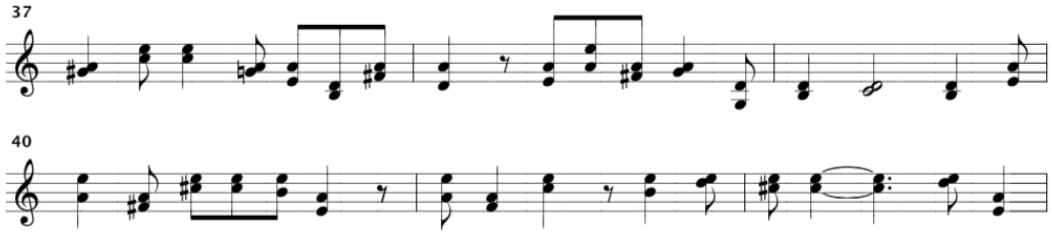


Figure 6.1.5 *Slip Minuet, mm. 37–42*

Objectively, one may be more 'correct' than the other—to my hearing, the second iteration contains a more stable difference tone (G, two octaves and a Major third below the B) which suggests to me that I may have 'overshot' the width of the interval in the first iteration. However, little would have been gained in this research context by testing the intonation of these two thirds through quantitative means. Arnold might agree, having once quipped, 'I'm interested in tuning systems; I'm also interested in *out of tune*, and how that happens.'

My aim in projecting a tuning system in the manner described here is never to be prescriptive, nor to impose absolute values against which any eventual practice of the piece might be measured—rather, its inherent constraint affords me the luxury of *surprise* in my own playing. Arnold, too, expresses a delight in this messiness:

> Once you get into the empirical or phenomenological, whichever way you want to take it, the great thing about any ephemeral experience is that no two are ever the same… Even if you could make everything around them the same, which fortunately you can't, they wouldn't be *actually* exactly the same—the listeners' ears aren't going to be exactly the same in terms of where you've taken them, the headspace they're in. For me, the thing that is so crucial about [this JI practice of intonation in this piece], is that [it brings] a focus into the playing that is mesmeric.

Learned responses and received practices can accumulate in the technique of experienced string players—the impulse to favour melodic voice leading, for example, or to cushion ambiguous harmonies with vibrato—and these embodied reflexes may push the experience of playing toward the formulaic. By filtering those tendencies through the creative constraint of a tuning system, I am provoked to release my preconceptions about the music and immerse myself in the presence of the process. The practice of intonation becomes a carrier for a wider practice of listening:

> At the core of my listening is a specificity and particularity of a kind of *moment*—not a precious moment frozen with importance—rather, within continuous music, the idea of really trying to flow along with the music, where you're absorbed in the detail of it. […] What I like about music is that it moves away from discourse, and part of that is that you don't feel the presence of the composer or the performer implicated in it. The piece belongs to everybody, whether you're supposedly the listener or the performer. What I don't want is for anyone to play my music dramatically, or like there's a character there that they are representing. I want them to play it like it's some kind of strange folk music of their own. That's really the thing for me: I like the detail to come from a sense of *being* with the music.

Arnold's above reflection emphasises a holistic experience of playing and listening with which I feel deeply aligned, recalling Nancy's 'listening subject' (see Chapter 4.5) who, in listening, becomes 'no subject at all, except as the place of resonance' (Nancy, 2007: 22).

What I carry forward

The practice of *Slip Minuet* outlined here has contributed significantly to my technique in 1) the accessing of low-order intervals, 2) the recognition and use of difference tones as proportional markers in tuning intervals, and 3) the application of annotations as material components in embodied practice. The ratio and cent annotations exemplified in Figure 6.1.4 appear only intermittently in my working score, and represent sonorities that are now wholly internalised and *known* to me as embodied technique.

In light of this process, which gives evidence of an epistemic cycle of embodied practice—in Spatz's (2015: 26) words, being 'structured by and productive of knowledge'—the question of whether *Slip Minuet* is in fact a practice of intonation or of microtonality seems increasingly less relevant. To invoke Gilmore's apt description (1995: 458), this practice has increased the sensitivity of my observation strategy when reading any simple interval. This grounding also enables me to push my technique into accessing more complex areas of tuneability, as examined in the following section.

6.2 Chiyoko Szlavnics: *Freehand Poitras* (2008)

Chiyoko Szlavnics' *Freehand Poitras* for two violins and cello was composed in 2008. This portfolio submission (Appendix A, Track 2) is played by Apartment House (Gordon MacKay, Anton Lukoszevieze and myself) and was recorded by Simon Reynell at Phipps Hall, University of Huddersfield (UK) in August 2016, and released on Another Timbre (at108 *Chiyoko Szlavnics: During a Lifetime*) in May 2017. This concise work (of variable duration) compels some of the same patterns of intonation technique exemplified in *Slip Minuet*, observed here in an ensemble context.

The piece is structured by repeated measures containing single harmonic events, in which two static voices (Violin 1 and Cello) establish precise harmonic relationships, comprising two or three tones, while a mobile voice (Violin 2) introduces gradual glissandi between two further precisely tuned pitches. I play the mobile voice in Apartment House's recording, which will be discussed here with respect to patterns of intonation technique relevant to the negotiation of *region of tolerance* in tuneable intervals, and as these intervals are rendered across multiple repetitions. All three parts will be discussed with respect to patterns of intonation technique relevant to the sounding of close-position intervals in specified proportions, or 'harmonic identities'.

Harmonic Identities

In contrast to Martin Arnold's 'common praxis' notational approach, Szlavnics uses a combination of explicit microtonal notation systems to represent precise relationships and sonorities—these include cents, partial notation[4], and Sabat's *HEJI Pitch Notation.* Alongside this already precise score, Szlavnics also provided us with an annotated *Rehearsal Score* (Figure 6.2.1) which denotes alternative ways of hearing and accessing notated pitches.

One such example can be seen in m. 2 [0:23] (Figure 6.2.1), in which the arrival pitch C# (-14) can be achieved either by hearing this pitch as the 15th partial of a previously stated D, or more probably (as Szlavnics suggests) as the 5/4 third over the cello's A. This second option is in my

[4] Partial notation specifies a fundamental (pitch or string number) and overtone (e.g., G^{13} or III^{7}). See Figure 6.2.1.

view the more viable, and also reveals what is for me a crucial point of interest in this piece—the capacity of a single pitch to take on what Szlavnics calls multiple 'harmonic identities':

> Each harmonic identity can relate to its fundamental, but it can also relate to many other pitches within a ratio network, and the perception of that same note can vary greatly depending on its new contextualisation by a different pitch. I enjoy the fact that there might be an ambiguity or multiplicity of perceptions, depending on a context that changes. (C. Szlavnics, personal correspondence, November 2018)[5]

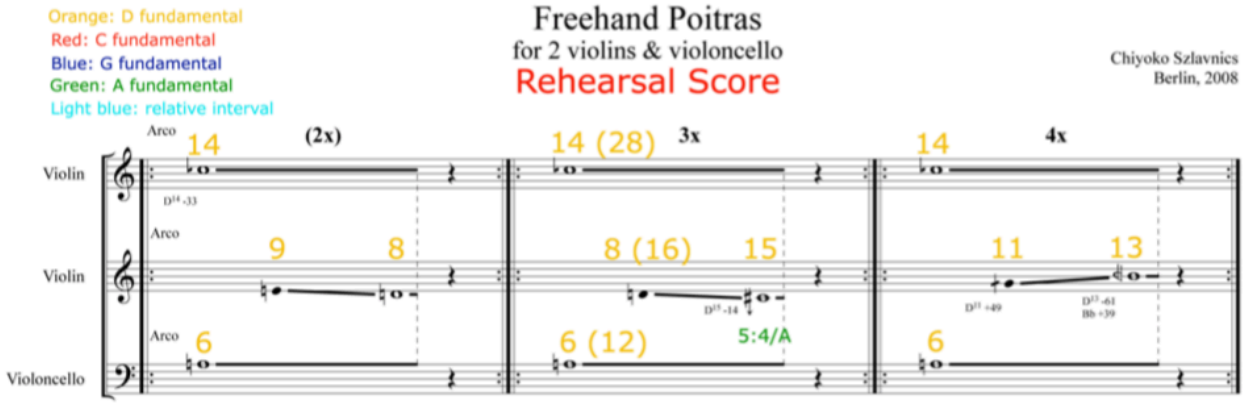


Figure 6.2.1 Freehand Poitras*, Rehearsal Score, m. 1–3*

In the given example of the C# (-14) in m. 2, my preference for defining the arrival of my glissando as 5/4 on A makes the actual location of my pitch contingent upon the pitch being sounded by the cello. I understand that the cent deviation (-14) is indicative of, but *secondary* to, that sonority, which my technique allows me to recognise as the 5/4 proportion. Szlavnics describes how sonorities may become internalised and applied within various degrees of harmonic complexity:

> … if you know the sound of a pure fifth (3:2), you should, theoretically, at least, be able to find and produce a pure fifth in *any* context. The notes of that interval might have complicated-looking ratios in a given pitch context, but the two notes—on their own—are simply a 3:2… The simpler ratio is clearly the easier one to understand, and yet further understanding is then possible with the other ratio definition(s).

[5] All comments from Szlavnics cited in this section are taken from a personal correspondence, November 2018.

A clear example of what Szlavnics calls 'relative intervals' (represented in Figure 6.2.2 in light blue) occurs in the penultimate measure of the piece, where my F# (-16) corresponds to the 5th partial of the presiding D fundamental, but also forms other tuneable relationships with the pitches sounding in other voices, including: a minor 6th (5/8) with the D (-2) in Violin 1, a perfect fifth (2/3) with the C# (-14) in Violin 1, and a perfect fourth (4/3) with the B harmonic in the cello. In theory, a triangulation of relationships can help to establish a confident sounding of this harmony. The cello's B provides a stable (and, as a harmonic, less flexible) reference pitch below which I tune my F# as a perfect fourth (4/3); my F# forms a pure fifth (3/2) with the C# in Violin 1; the minor second (15/16) in Violin 1 is itself tuneable, but will also result if the D forms a minor third (6/5) with the cello's B harmonic.

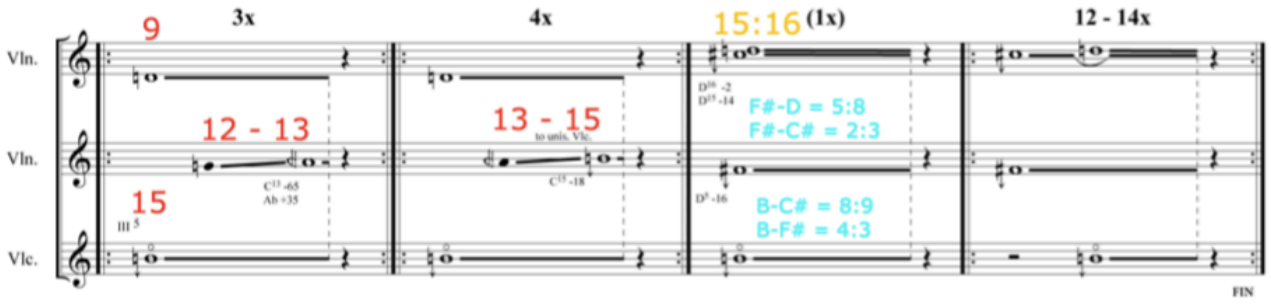


Figure 6.2.2 Freehand Poitras*, mm. 14–17 [7:05]*

In practice, Gordon and I found it appropriate to prioritise the 3/2 fifth between my F# and his C#, which is the simplest relationship in the cluster, and which also emerged most apparently when we sounded the complete chord [8:20]. We therefore had to thread a careful negotiation in which the proportion of our fifth was retained, while remaining in an accurate relationship to Anton's B harmonic—a different sort of triangulation.

Regions of Tolerance

Tenney's (2015: 294) and Sabat's (2006: 3) discussions of *regions of tolerance* are materially evidenced in the technique elicited by the glissando gestures that occur throughout *Freehand Poitras*. Szlavnics describes attending to these gestures as an exploratory experience of the glissando continuum:

> I was struck by the particular qualities of pure intervals, that is, justly-tuned intervals, or ratio-based intervals, when I first practiced them around the year 2000. […] I was fascinated by the fact that such intervals can really be perceived and achieved, and was equally fascinated by the tiny zone around them, by non-unisons that create beating. […] I enjoy that very moment when an interval reaches its tuning, or when a non-unison finally reaches unison. There is something extremely satisfying in that moment for me.

As each glissando arrives at its resting relationship, it should form a tuneable interval with one or both of the static voices already sounding. The recognition of these arrival points depends on technique which allows me to perceive the point where 'nearly in tune' (Sabat and Hayward, 2006: 3) becomes *in tune*. The glissando in m. 15 (Fig. 6.2.2) [7:37] is a clear example of a complex harmonic identity, which then converges on a unison B (-18) with the cello. This unison, which Szlavnics characterises as the interval *reaching its tuning,* is registered in my technique as a clearing of turbulence in the sonority of the interval.

In other instances, less obvious points of reference are available to facilitate the reaching of a tuning: in m. 7 (Figure 6.2.3) pitch material is taken from higher partials (between 7 and 18) of an unstated C fundamental. I am required to sound a glissando between the 15th and 18th partials, neither of which I found to be reliably tuneable in the context. Instead, as suggested in the Rehearsal Score, I tuned to a G reference (stated in Violin 1) giving the same pitches through far simpler, easily tuneable means (B as 5/4, D as 3/2). The chord heard by an outside listener [2:35] is, in a practical sense, not the chord being activated in my technique, which exists primarily in my aural imagination.

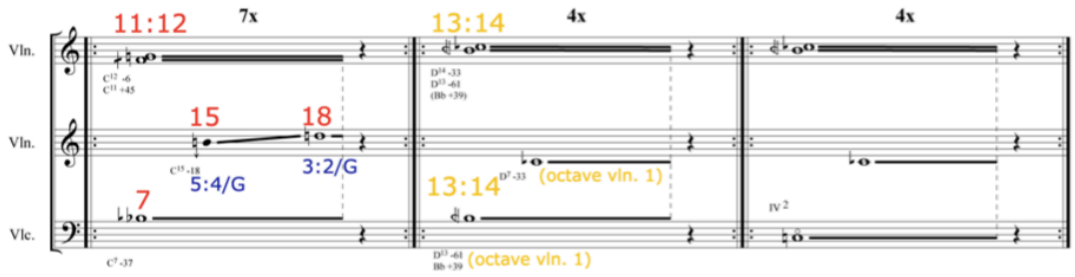


Figure 6.2.3 Freehand Poitras*, mm. 7–9 [2:35]*

Repetition

The manner of pitch recognition described in m. 7 has taken time and repetition to incorporate into my technique, and in addition to an active aural imagination, relies to some extent on proprioceptive memory of pitch locations (i.e., recalling the *feeling* of a B tuned as 5/4 on G), and to some extent on knowing how a pitch sits in the resonance of the instrument when it forms a low-order interval with an open string.

My starting pitch in m. 7 (B -14) is very familiar in my technique, being both 5/4 on G and also 5/3 on D, and I was able to rely on years of experience playing 'in tune' intervals in the keys of G and D Major to access this pitch reliably. Still, in the context of the other pitches sounding, this familiar B was challenging to access, and this impression became more apparent in the course of the seven repetitions of this measure. On a technical level, my aim was to approach each new iteration of this B afresh, audiating the 5/4 on G. This instinct is echoed in Szlavnics' contemplations on her own musical experience of this material: 'How can every single iteration be infused with fresh energy, as if it were the first measure of a piece, in each case?'

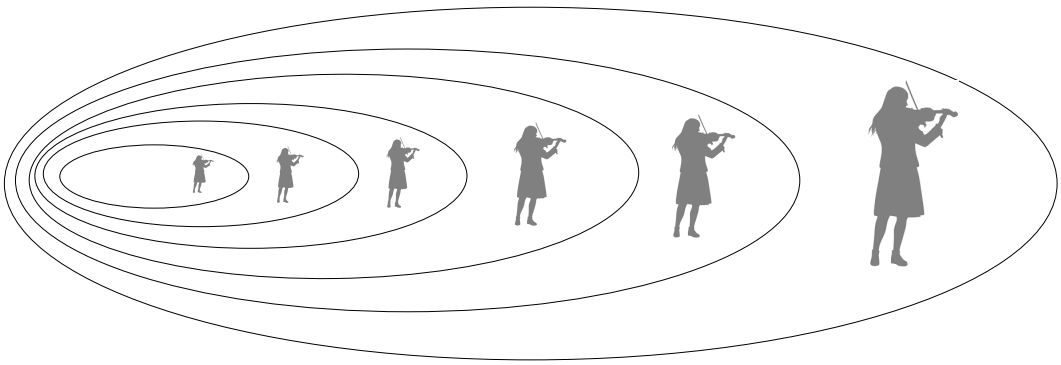


Figure 6.2.4 *Embodied experience of repetitive practice*

My experience of playing these iterations, however, is more akin to *progression* than either repetition or recommencing. Each new iteration of m. 7 contains, and is contextualised by, all the previous ones; the residue of each begins to *tug* at my technique (in my tissues and in my memory of the pitch). My internalised aural impression of B (5/4)—which already forms complex relationships in the harmonic context—is infiltrated by the embodied recollection of previous Bs, and subjected to further relational contexts. The sense of progression which for me characterises

this practice does not mean that my renderings become more perfect—to the contrary, my experience of these intervals becomes messier, and I have the impression that the first iteration was technically more straightforward than the seventh. Small variations of pitch in these seven Bs is inevitably present in the recording [2:35].

Like Arnold, Szlavnics reflects a generous view of this human messiness, speculating that her repetitions might be experienced by both performers and listeners

> as either wearisome, or as something completely new. It is impossible to repeat material like this precisely, so the variation during performance can make each repetition exciting. […] It is this tension that makes the performance interesting to listen to.

This same tension also renders my practice of the piece 'interesting'. My commitment to the pursuance of sameness across each repetition represents for me what Schwab (2015: 122) calls an 'experimental system', from which *ruptures* in my practice then reveal new insights about the technique.

What I carry forward

The practice of *Freehand Poitras* described here has grown my technique 1) in the accessing of low-order intervals within the context of more complex 'harmonic identities', 2) in negotiating regions of tolerance as material explorations of tuneability, and 3) in the reflection on these negotiations afforded by repetition.

This practice was substantially influenced by the availability of the Rehearsal Score, which served to clarify points of relational comparison that might otherwise have been revealed only in the process of making my own annotations. The Rehearsal Score did not, however, entirely duplicate the function normally served by my own practice of annotation, and while it accelerated the learning process in some respects (most specifically in that it enabled me to access pitches 'accurately' in a short rehearsal time frame), that acceleration also bypassed some aspects of 'unpacking' the score.

The most important of these—a *seeking out* of relationships, which often accompanies my annotation process—was retrieved through the practice of *closing in* on harmonic identities, afforded by the glissando material. In pursuing *sameness* in these gestures, their inherent

difference was then highlighted: the indeterminacy that emerged across multiple iterations revealed an epistemic object of the practice that, rather than concerning itself with a pursuance of intentionality, was rooted in the opening up of my reflective awareness of relationality. As previously observed in the work of Martin Arnold, *Freehand Poitras* became an absorbing, variegated practice of listening.

The potential for *thickness* in a relational technique of intonation is palpable in Szlavnics' very personal comments on her own listening practice:

> On a theoretical and imaginative level, working with different "harmonic identities" also allows me to roam quite freely within a world in which there are distinct intervallic sounds, almost like characters, but where there is also so much potential for creating networks between pitches.

This relational epistemology of pitch, which lies at the heart of this research, is examined through more complex patterns of intonation technique in the following sections.

6.3 Howard Skempton: *Tendrils* (2004)

Howard Skempton's *Tendrils* for string quartet was composed in 2004. This reference recording (Appendix A, Track 3) was taken at a live performance by the Bozzini Quartet in Montreal, Canada, 19 April 2013. The piece is discussed here as it illustrates patterns of intonation technique relevant to the negotiation of chains of Just intervals, and group predictive tuning strategies.

A Fundamental Asymmetry

Tendrils comprises 55 short canons at the minor sixth, traversing many degrees of harmonic modulation, with pitch material taken uniformly from Messiaen's third mode of limited transposition (Figure 6.3.1). Common Practice Pitch Notation is used, as is consistent with Skempton's practice.

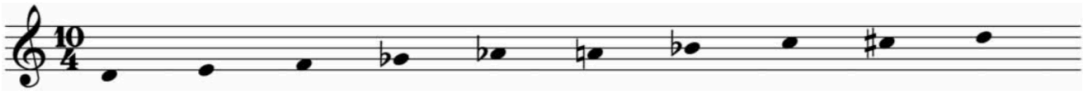


Figure 6.3.1 *Messiaen's third mode of limited transposition* (Fox, 2014b: 275).

In correspondence with composer Bryn Harrison, Skempton remarks that 'the effect of transposing each entry up (or down) a minor sixth' creates an effect that is 'kaleidoscopic, giving the impression of continuous modulation' (Fox, 2014b: 275). Commenting on the apparent symmetry of Skempton's canonic harmonies, Harrison observes that '[stacked] minor sixths return to their original pitch two octaves higher (i.e., E-C-A flat-E again) so that bar 4 in the violin is the same as bar 1 [in the] cello' (Fox, 2014b: 276), which Christopher Fox suggests provokes 'a sense of completion which, in turn, necessitates a response, the next canonic entry' (Fox, 2014b: 276). This feature, which Skempton describes as lending a 'miraculous' quality to the work (Fox, 2014b: 275), furnishes some substantial challenges for a quartet's practice of intonation.

Two main challenges present themselves in the practice of *Tendrils*. The first, which concerns identifying *reference pitches*, arises because each player's pitch material within the canon structure functions both as a self-contained melodic line and as one quarter of a closely-voiced, nearly-homophonic harmony. The practical differentiation between melodic and harmonic voices, discussed in Chapter 4 as potentially contributing to a simultaneous/successive tuning paradigm, is thus obfuscated.

While Skempton does not prescribe any specific approach to intonation in this piece, several factors lead the Bozzini Quartet to preference consonant, low-order simultaneities in our 2013 realisation[6]. Skempton's modulations bear fleeting resemblances to functional harmonic resolutions—qualities which reinforced the quartet's established tendency toward relational tuning. Given the frequent occurrence of strongly audible consonances (perfect fourths, fifths, major and minor triads) throughout these modulations—as well as our established preference for non-vibrato playing—our quartet arrived at a practice which prioritised the intonation of simultaneities over melodic voice leading. Such an approach can lend definition to discrete areas of harmonic reference, and in the same manner discussed in Martin Arnold's music (6.1) can

[6] I note that this realisation was informed by the Bozzini Quartet's prior recording (2007) of Skempton's quartets, in which I was not playing.

streamline the learned responses and received practices of the players, contributing to a more cohesive ensemble sound.

This solution to our first challenge, however, reinforced the existence of a second challenge: in attending to the intonation of simultaneities, we found ourselves inevitably *modulating* microtonally through chains of pure intervals (Figure 6.3.2) as we drifted farther from each initial reference pitch. The ascension by minor sixth, which Harrison finds to be pleasingly symmetrical, is in practice a source of fundamental *asymmetry* in a relational technique of string quartet intonation.

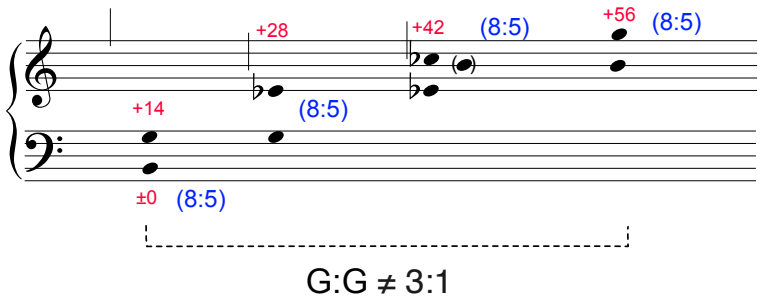


Figure 6.3.2 *Chain of Just minor sixths*

Here, each minor sixth (8/5) is 14 cents *wide* of a 12-EDO sixth, contributing to an overall modulation of +56 cents across two octaves. As illustrated above (Figure 6.3.2), an intonation strategy rooted rigidly in Just Intonation can quickly lead players to arrive at octave *inequivalence* with initial reference pitches, and to thus establish new reference pitches which are substantially deviated from the tuning of their instruments. Taken in context (Figure 6.3.3), and assuming that each successive reference pitch is reached through a similar chain of Just minor sixths, this tuning strategy would result in an upward modulation of more than 50 cents in just four bars.

In the example below, the introduction of a pedal B (+42) in measure 67, results in the eventual arrival of a new root E (+40) in measure 70, which will serve as the reference pitch for the next canon iteration. It is easy to foresee how, given several more canon sequences, a quartet might modulate far enough out of tune with their own instruments to render playing prohibitively complex.

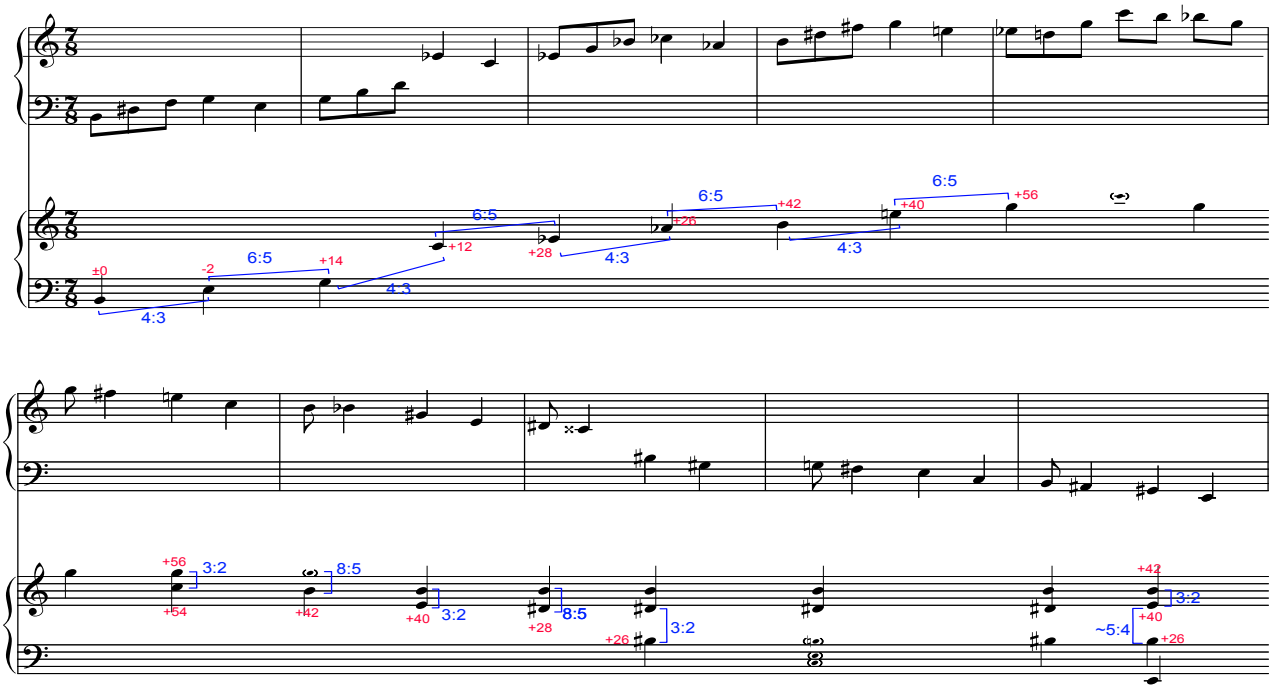


Figure 6.3.3 *JI annotation of pitch centres across mm 61–70 of* Tendrils

Intonation Drift

In a harmonic texture as various as Skempton's, alternatives to a pure, chain-based tuning practice may appeal. Perhaps the most straightforward approach is to apply some measure of vibrato, which obscures the immediacy of pitch relationships in much the same manner recommended by Galamian, discussed in Chapter 4. Skempton, an accordionist, might not object to this strategy, having once quipped, 'I don't want vibrato, but I want the *possibility* of vibrato' (H. Skempton, personal communication, 1 July 2017). My persistence with the laborious task of tuning *Tendrils* without vibrato and with attention to low-order simultaneities is, for me, justified in my whole-hearted agreement with Skempton's appraisal that a 'miraculous' experience of sonority can arise from such a practice.

The approach explored here involves re-orientating not the pattern of intonation technique (which remains rooted in low-order ratios) but the strategy through which reference pitches are obtained. This approach is informed by vocal synthesis scholar David M. Howard's research on the intonation strategies employed by *a capella* SATB quartets. Howard notes that SATB vocal quartets, like string quartets, tend toward 'non-equal temperament', and that as a result they inevitably experience 'intonation drift' with modulation (Howard, 2007: 300). Rather than

seeking to correct this tendency, Howard (2007: 314–15) writes that 'it can be cogently argued that [intonation drift] is the only way to remain in-tune', suggesting instead that if correction is required for practical or artistic reasons, alternative strategies should be considered,

> perhaps based on finding a point in the music where a pitch shift can be employed[,] or by conscientiously modifying the tuning along the lines adopted by the American Barbershop singers. (Howard, 2007: 315)

The strategy here alluded to by Howard is described in greater detail by American Barbershop vocalist Jim Richards in his account of Barbershop vocal technique:

> The Lead has the responsibility for singing the melody and staying in key. The harmony singers support the Lead by singing harmony in tune with the melody…. Essentially we use just intonation for harmonic tuning while remaining true to the established tonal center. (Richards, 2001: 16)

Howard's studies of intonation drift in SATB ensembles support Richards' account of a dominant (in this case *melodic*) line functioning as a *mobile reference pitch* around which other voices tune, with a general attention to consonant simultaneities. Howard's 2007 study on this topic (Figure 6.3.4) reveals the difference between predicted drift of an ensemble (taking a strict JI reading as the basis of the projection) and the actual drift of the ensemble in controlled practical tests.

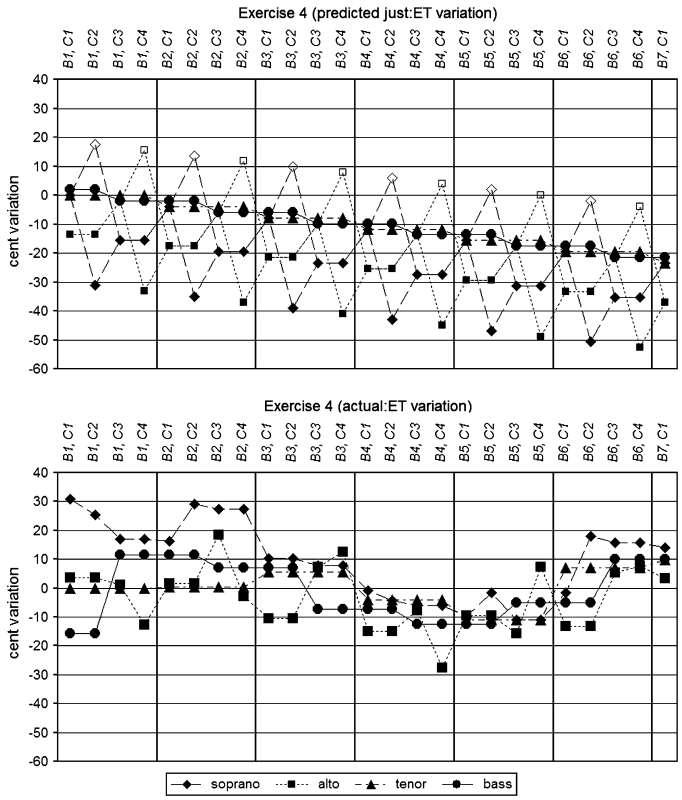


Figure 6.3.4 *Intonation drift in a capella singing (Howard, 2007: 311)*

Here, the top graph shows the predicted drift of an SATB vocal quartet performing a passage in strict JI. An overall drift of approximately 22 cents is projected, meaning the quartet will arrive at a pitch centre about 1/10th of a tone lower than their initial reference pitch. The bottom graph shows the actual pitch drift of a quartet performing the exercise. The overall contour of this graph describes a general adherence to Just intonation (particularly in the downward pitch drift around measures four and five), however certain obvious interruptions in that downward drift indicate that adjustments have been made. It is apparent that at key points during the passage, one or more of the singers redirects the harmonic movement for practical or other musical reasons. As a result, the starting pitch centre is approximately retained at the end of the passage.

Predictive Strategies

The strategy characterised by Howard's diagram seems very well suited to the challenges posed by *Tendrils*, because it allows the players to prioritise the intonation of consonant simultaneities, while retaining some flexibility with regard to 1) the overall pitch centre and how it sits in the

established tuning of the instruments, and 2) how the canon subjects are performed as melodies. The following annotation of the canon section between mm. 61–70 prioritises low-order tunings for simultaneous pitch relationships, while making local decisions in the successive relationships that keep pitch centres rooted to one of the five open strings (Figure 6.3.5). This decision means that some measures are tuned to a *sounding* reference pitch, while others are tuned to an *unstated* reference pitch. The overall tuning strategy might be called *locally Just, globally Pythagorean*.

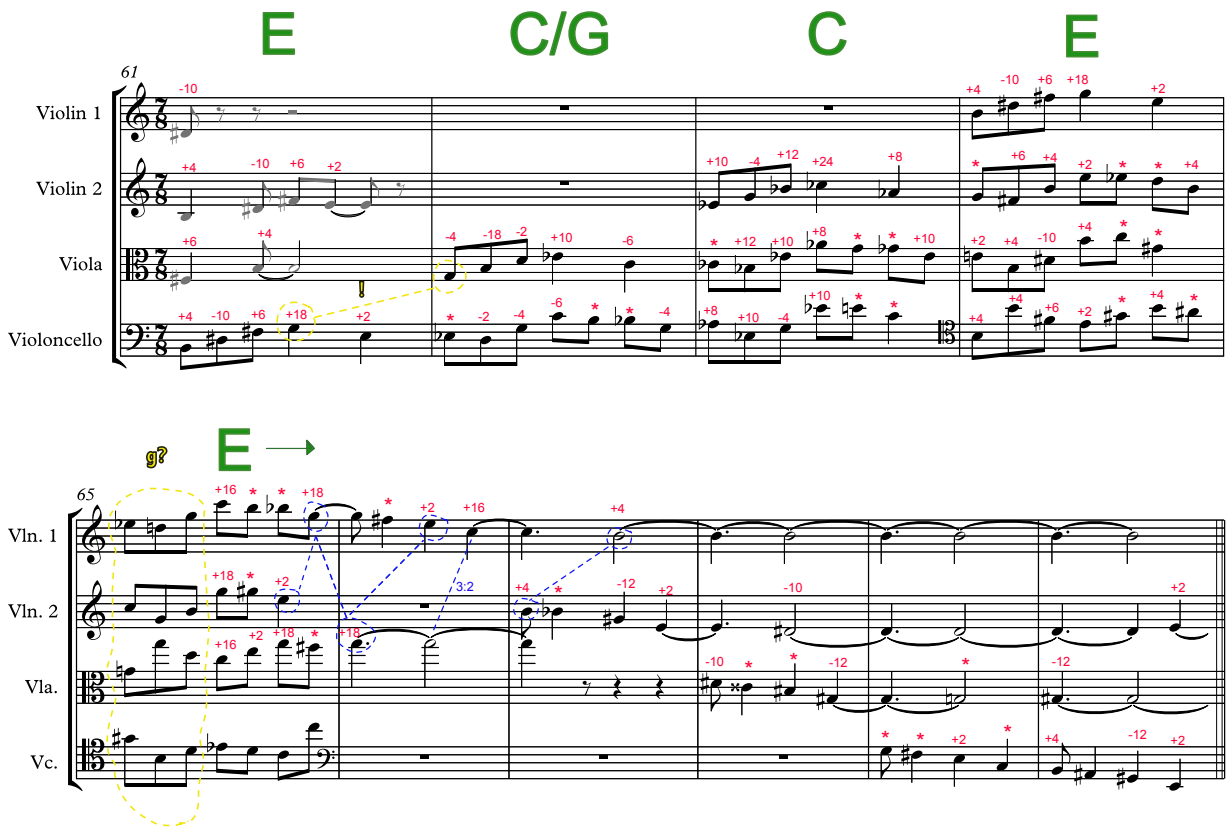


Figure 6.3.5 Tendrils*, mm. 61–70 [4:09]*

In the above example, the alteration in intonation necessitated by a changing reference pitch is clearly illustrated in the difference between the fourth pitch in each canon entry, and the subsequent first pitch in each new entry. In measure 61, the reference pitch E (+2) forms a minor third (6/5) with G (+18). In the following measure, a new reference pitch of C (-6) requires the viola to intone the G (-4) 22 cents lower. An analogous alteration is, however, unnecessary between measures 62 and 63, as the root C is retained, and the intonation of the E-flats can remain consistent between the viola and the second violin entry.

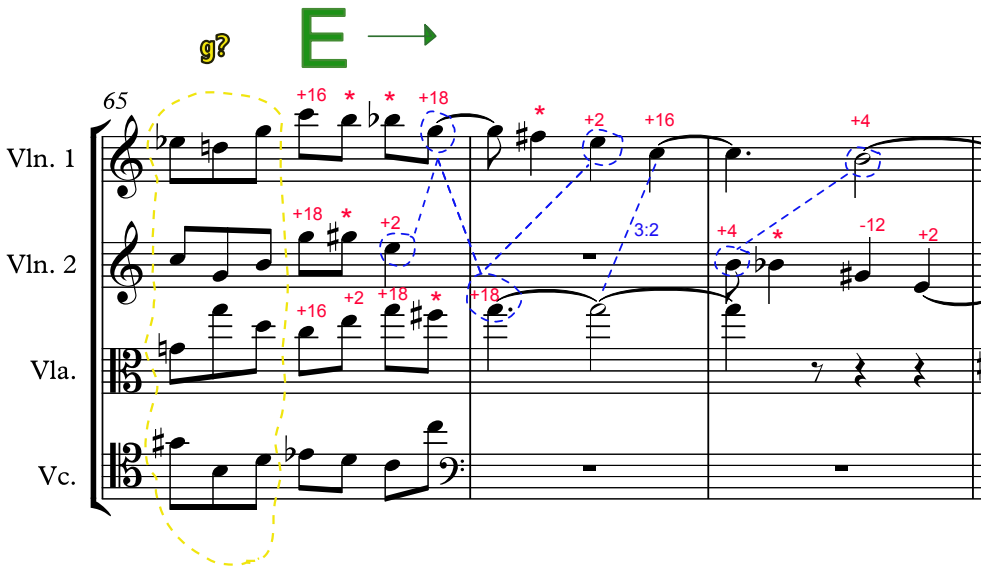


Figure 6.3.6 Tendrils*, mm 65–67*

Particular intonation challenges arise in m. 65: in the first three quavers, a potential G reference pitch is obscured by rapid harmonic movement and a high degree of chromaticism between voices. In this moment, like many others that appear periodically throughout the piece, it is likely that a quartet might take a looser approach to harmonic intonation, opting instead to tune these pitches successively as they approach a more stable common reference pitch. This stability arrives in the last four quavers of the measure, where I have identified E (+2) as a stable reference pitch, not because E is a particularly obvious root for any of the pitch material in this or the immediate subsequent measures, but because this predictive strategy facilitates a crucial transition toward the end of the canon section.

This canon section resolves on an E major triad at the end of m. 70, following three measures of pedal B, which might have the tendency to be heard as a prolonged dominant of E. To avoid the uncomfortable upward modulation described in Figure 6.3.3, the B pedal introduced in m. 67 can be tuned to an unstated E reference, in anticipation of the eventual resolution in the last crotchet played by violin 2 in m. 70. The same E reference can be pre-empted in measures 65–67 (Figure 6.3.6): E (+2) played by violin 2 (m. 65, last crotchet) forms a minor third (6/5) with G (+18) in violin 1, leading to a octave (2/1) G pedal in the viola (m. 66) and an eventual major third (5/4) with the B (+4) in violin 2 (m. 67). A strategy such as this might account for the harmonic interruptions or redirections observed by Howard in his studies of intonation drift.

Reflecting on prior practice

The preceding examples are not literal descriptions of the techniques and strategies employed by the Bozzini Quartet in our 2013 realisation. They are, however, informed by many of the finely developed techniques of relational tuning which, while perhaps less explicitly represented on the page, were crucial to establishing the group's signature playing aesthetic and sound.

My interest in following that implicit practice (with which I became intimately familiar) to this more explicit evaluation of patterns of intonation technique, springs from the strength of my recollection of both the extraordinary challenges we encountered in tuning this piece, and also what that practice revealed to me about the inherent capacities and pitfalls of relational intonation technique. In revisiting that prior practice through the lens of this research, I note qualities in the playing which suggest points of concurrence with the strategies described in the above analysis.

For example, listening to the canon at m. 61 [4:09] a notable use of the open E-string by the violins suggests an intonation strategy that agrees with my *locally Just, globally Pythagorean* assessment. This is particularly noticeable across both violin parts in mm. 65–66, where obvious open Es form consonant minor thirds with Gs (first between the two violins, and then between violin 1 and viola). In order for violin 1 to arrive at the third pitch in m. 66 on an open string as this consonant third with the G already sounding in the viola, the violist must have tuned her G as a pre-emptive third on E, and not to some other reference (such as her own open G). Additionally, noticeable alterations in pitch across entrances point to shared reference pitches—for example, the intonation of the violist's entering G in m. 62 sounds noticeably lower than that of the cellist's G, two crotchets prior, which agrees with the analysis posited in Figure 6.3.5.

What I carry forward

In outlining the precise tuning patterns proposed here, I do not mean to suggest that a note-by-note cent deviation annotation is a practical (or even constructive) method for a quartet to adopt in developing a realisation of *Tendrils.* My own playing score certainly does not display a cent marking on every pitch, although I do use intermittent annotations to guide my intonation technique at strategic moments.

I would argue, however, that a detailed practice of intonation in this piece demands a *mutual understanding among the players* regarding constantly shifting, often *mobile* reference pitches,

and additionally that in certain crucial moments, predictive or anticipatory strategies are required to facilitate larger-scale (multi-measure) intonation patterns. Such strategies can also enable ensembles to negotiate harmonic environments defined by varying degrees of indeterminacy, as will be examined in Section 6.5 with the work of John Cage.

The substantial contribution to this research afforded by this reflection on *Tendrils* is in its illustration that the prediction or anticipation of tuning patterns essentially requires a *partitioning* of my technique. In other words, in order to audiate one thing while another thing is physically sounding, I need to compartmentalise the manual, observational and reflective components of technique that, until now, have been discussed only as they function together as an integrated, embodied process. This partitioning of elements of technique will be explored further in the next section with the work of James Weeks.

6.4 James Weeks: *Windfell* (2017)

James Weeks composed *Windfell* for me in 2017, as a commission with support from the PRS Foundation, UK. This portfolio submission (Appendix A, Track 4) was recorded by Simon Reynell at St Paul's Hall, University of Huddersfield (UK) in November 2018, and released on the Another Timbre label (at139 *James Weeks: Windfell*) in May 2019. This 60-minute continuous piece for solo violin is structured in twelve sections (I–XII), and scored using HEJI Pitch Notation with additional cent deviations.

Sections VII to X will be discussed here with respect to patterns of intonation technique relevant to the sounding of *septimal* and *undecimal* tuneable intervals, the placement of these intervals in *relational sequence*, and the introduction of *bodily sounds* (singing and whistling) into the technique.

Bodily Sounds

Pitches produced from within the body—either sung or whistled—occur throughout *Windfell* as components of precisely tuned dyads and clusters. I have almost no vocal training; I have taken one voice lesson in my life, with mezzo-soprano Lucy Goddard, in preparation for this piece. I

feel much more secure in my ability to produce purposeful pitch on the violin than I do with my voice.

Upon reflection, the main technical difference between *singing* and *playing* a pitch lies in the enactive physical area of technique (what I have been calling *manual* technique in prior discussions). Observational and reflective components of both techniques are much the same—that is to say, I audiate a voiced pitch in the same manner that I do a played pitch; my internalised aural impressions of both are activated in the same way; the same cognitive and symbolic representations can feed into both reflective dynamics. These insights might explain why I find it difficult to sing and play at the same time: two distinct, simultaneous processes are drawing from the same areas of my technique.

The negotiation of voiced and instrumental pitch in various combinations throughout *Windfell* relies on sorting audiated and enacted events into manageable sequences. In general, my preferred order is to establish (or prepare) violin pitch(es) first, and then tune the voice in relationship. Weeks was aware of this preference during the composition process, and built some helpful mechanisms into the score: sung pitches nearly always form a tuneable interval with one or more pitches already established on the violin.

For example, in section IX [45:00] I establish a fifth (3/2) with the open A and D strings, and then sing intermittent pitches above this drone. Each of these pitches forms a tuneable interval with either the A or the D (Fig. 6.4.1). First, C (-33) is the septimal seventh on D (7/4), and this interval is reinforced by the A, forming a Just dominant seventh (4/6/7). Next, my reference pitch changes to A, and I sing a Just minor third (6/5), effectively ignoring the D in my audiation.

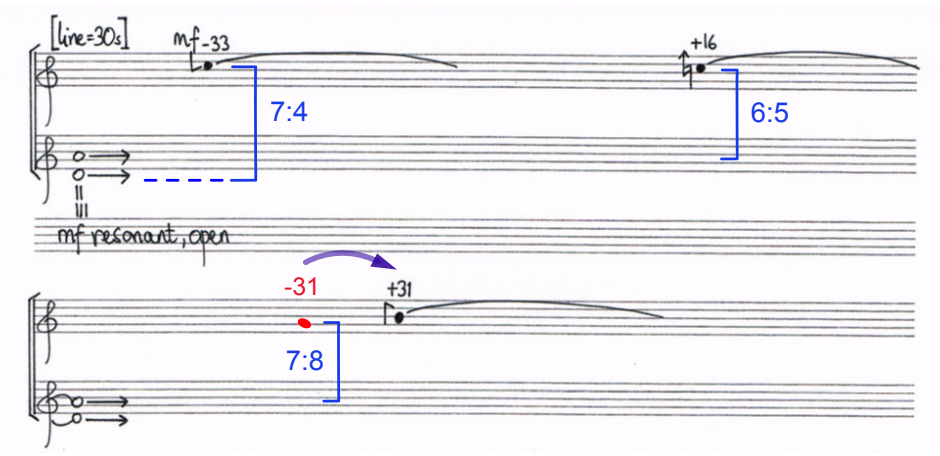


Figure 6.4.1 Windfell*, Section IX, second page [45:00]*

The third pitch in this sequence is found through a more indirect audiation—I imagine this *upper septimal* pitch as the mirror interval of the septimal seventh of A (7/8), and then invert that proportion to hear a pitch which is an equal distance (131 cents) above the A. The interval retains the 7/8 tuneable ratio.

Holding and Matching

Drones, as seen in the above example (Figure 6.4.1), provide stable references on which I can tune vocal pitches. In much of *Windfell,* however, harmonies are intermittent and rotate rapidly, and I cannot rely on a consistent instrumental reference pitch as a basis for vocal intonation. In such cases, sung pitches must be accessed by means of unstated (audiated) references, or by successive relationship to earlier stated pitches. Once again, Weeks anticipated this challenge in the composition process—pitch content is often stated in the violin *prior* to being stated in the voice, allowing me to hear an *externalised* version of a pitch that reinforces my audiation before vocalising. In Section VIII (system 3) each of the vocal pitches is sounded as part of a dyad in the violin directly before it is sung as a component of a more complex clusters (Figure 6.4.2). My sequence of technique here might be crudely described as follows:

1) prepare chord 3: audiate the 8/7 interval
2) sound it, register the pitch of the G (-31)
3) prepare chord 4: audiate the 5/4 third, *prepare the embodied action*
4) sound the 5/4 third, but redirect audiation back to the G (-31, 8/7)
5) rely on the hand to retain the 5/4 third (which is reliable in my technique) and observe the 8/7 second—(subtly) adjust the sung pitch if necessary

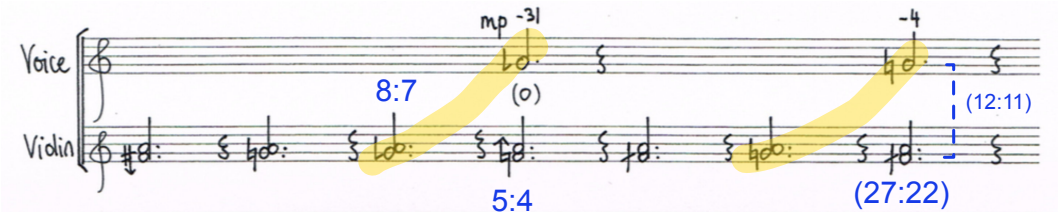


Figure 6.4.2 Windfell*, Section VIII, system 3 [38:05]*

In much the same manner I can then sing a stable G (-4) three chords later, within an even higher degree of harmonic complexity. This same pattern of technique is effective where staggered changes let me *piggyback* audiations on established pitches (Fig. 6.4.3). In Section VII (beginning in system 6) the septimal F (-35) is difficult to tune in the context of the F# (-16) also being sounded; the 14:15 semitone is not an interval which I find reliably tuneable—nor, incidentally, does it appear on Sabat's list of intervals tuneable by ear (Sabat and von Schweinitz, 2004: 17). My strategy here is to establish the 5/4 third in the violin, and then to audiate the septimal F as it will sound in the *following* chord (as 7/8 with G).

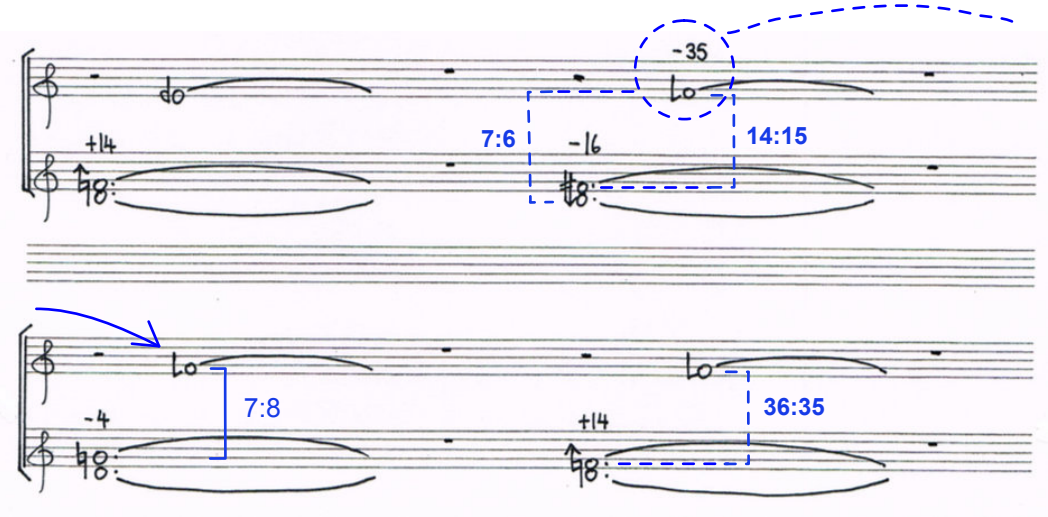


Figure 6.4.3 *Windfell, Section VII, system 6 [33:53]*

The capacity of my manual technique to sustain a pitch accurately while the rest of my technique is directed toward audiating and singing an entirely different pitch is entirely crucial to the practice of this piece. The violin affords a *splitting* of my technique—a holding of one pitch in the fingers, then a necessary *forgetting* about it while another is rendered in the imagination and voice.

'Placed in a world' (What I carry forward)

Throughout my conversations with the composers whose music features in this portfolio, a consistent thread has emerged: that intonation, in its various manifestations, enables something *else* to transpire.

> **Mira Benjamin:** What do you hope for or seek in the listening experience of a piece like *Windfell*, which foregrounds intonation in such a palpable way?
>
> **James Weeks:** For me, it's not enough just to demonstrate a phenomenon, or even to explore a phenomenon in the sense that I just want to hear it. I want to put it in a world somehow. […] The whole point of [using Just Intonation] is that [the intervals] are tuneable—they are embodied, as it were. I can hear them under my ear, I can *feel* them in my gut. They are for me *material* things, not abstractions, not ideas about interval size… they are tuneable *things*. (J. Weeks, personal communication, 4 Jan 2019)[7]

Weeks' remarks on the 'tuneable things' in his music are suggestive of Tim Ingold's (2010: 3) distinction between objects and things, in which a *thing* is regarded as 'a "going on", or better, a place where several goings on become entwined' (2010: 4). The 'goings on' of my technique are at the forefront of my attention in my practice of *Windfell*—manual, observational and reflective processes attend interchangeably to tasks, discrete and shared, that enable Weeks' gradated harmonies to sound. I wholeheartedly agree with Weeks that a given harmony in this piece is, as Ingold might put it, 'not an object at all, but a certain gathering together of the threads of life' (2010: 4).

[7] All comments from Weeks cited in this section are taken from an interview conducted on 4 January 2019.

MB: To call these intervals *things,* to me, carries an implication that they have their own dynamics, their own material agency… What, then, would be an *accurate* realisation of the notated score?

JW: I wouldn't sit in a recording session with my tuner out… There is for me a zone of 'right enough'. But fundamentally the point of the intervals is to be beat-less, because you can then create very rich combinations by putting two on top of each other. […] What I'm looking for is a manipulable richness of microtonal material. I'm looking for material that is graspable, where differences are palpable for the listener and the performer, and that therefore they can be meaningful. What I like about it is that I can hear it all.

MB: Most of the time, I feel I manage to stay within the zone of 'right enough', but the rigour of my practice depends upon striving for sonorities that are very precise in my imagination. In your mind, is there an ideal rendering of this piece?

JW: I don't want to fetishise, even on a recording, a perfect performance—there won't ever be a perfect performance of this piece, because even if one day you accidentally nail everything completely, with not the slightest deviation … there might be something lacking from that performance that was present in another… There are so many dimensions to what makes a great performance. There's always a point where you let precision go, and find what the actual music is. What I'm getting at is that tuning is only part of what the music is… it's only part of it.

To echo Weeks' remarks, which are very much in keeping with my own reflections on assessing my pitch accuracy in *Freehand Poitras* (6.2), I never used a tuner in the learning process or recording of *Windfell*—nor was I motivated, in choosing takes for the master, to test the intonation of harmonies rendered by electronic (or other quantitative) means. My impression in listening to the recording is that the intonation rendered was indeed 'right enough'—however, the effectiveness of the practice, and its contribution to my technique, cannot be measured by the 'accuracy' of a given rendering. In Weeks' remarks, as in Arnold's discussion of 'focus', or Szlavnics' reflections on 'harmonic identities', it is clear that this music is not about being *in tune*—it is about *tuning.*

MB: I take from your comments that at the end of the day, *Windfell* is about my commitment and relationship to the material. Or, perhaps, that the sonic signifiers of this practice are not the be-all and end-all of the music. Am I overstating this message?

JW: The whole poetic idea of this is the discovery of intervals, and the discovery of harmony… It's the idea of 'trying out'—of 'testing against the ear' and just 'tasting', if you like, each new sound as it comes out. Each new combination of tones as they come out is really important to me. I find myself drawn to these images of *discovering*—of *becoming aware of* sound, harmony, sonority… This is why the piece is so 'stripped back' and archetypal.

MB: Martin Arnold has described hoping a player will 'bring in their musicianship to shape' his music. In contrast, I perceive *Windfell* as an invitation to bring a *selflessness* to the practice, which then holds the potential to shape how I listen.

JW: I'm aware of the balancing of a kind of 'universalising' urge with a 'personalising' urge. The universalising comes through a kind of purification of my composition strategy. I find myself trying to purify the strategy to the point at which everything has an unimpeachable logic, at least in my mind.

Parallels suggest themselves between what Weeks calls his 'universalising urge' and my own projection of tuning systems (explored in Sections 6.1 and 6.3), which help me to sidestep potential learned responses and become (at least in part) a curious listener to the phenomena of my own intonation. The specificity already present in the notation of *Windfell* lends a singular clarity to the practice—symbolic descriptions of pitch relationality, in tandem with the embodied impulses they provoke in me, are certainly at the forefront of my experience. My fingers clearly occupy a central role in actualising this piece, however the *stripped-back-ness* of the material allows *listening* to surface as a primary carrier of content in the practice.

The perspective skirted in my dialogue with Weeks suggests that elements of 'personalising' which might be brought into a practice of *Windfell* are not necessarily a matter of intervening on the outward signifiers of the practice. Rather, as artist Paul Carter (2007) has poignantly testified,

‘invention begins when what signifies exceeds its signification’. Creativity and individuation in this practice, as well as rigour, are located in the internal, reflective processes of technique.

In this sense, my practice of *Windfell* represents a point of conclusion for this research: perhaps counterintuitively in the presence of such explicit pitch notation, this practice is not about controlling intonation—it is about participating in it. Much in line with Nancy’s philosophy of the ‘*renvoi* of meaning, sound and self’ (p. 121), *Windfell* tunes me as I tune it.

6.5 John Cage: *Four* (1989)

John Cage’s *Four* for string quartet (1989) is one of the group of compositions known as the *Number Pieces*, composed between 1987 and his death in 1992. These works share the primary distinguishing notational feature of durational *time brackets*, which determine the form and resultant interactions between musical materials.

This recording (Appendix A, Track 5) was recorded by Stephan Schmidt at CAMMAC Arts Centre in Québec (Canada) in September 2013, and released on the *collection qb* label (CQB 1414 *John Cage: Four*) in March 2014. *Four* will be discussed here with respect to patterns of intonation technique relevant to the negotiation of limited harmonic environments featuring probable degrees of consonance, in which the occurrence of simultaneities is indeterminate.

Time Brackets

The score materials for *Four* consist of four separate parts, which share a common sequence of flexible and fixed time brackets. The parts (1–4) can be played interchangeably by the quartet members, as all pitch material occupies the two-octave range common to violins, violas and cellos. The majority of the time brackets are flexible (Figure 6.5.1), meaning that material can occur at any point between the start-and-stop time indices indicated by the brackets, which in most instances specify a window of 22.5 seconds on either end of the bracket. The spacing of these time brackets, in which the earliest possible *stopping* time index occurs 7.5 seconds *before* the latest possible *starting* time index, leaves open the possibility that material within a time bracket may end before it begins.

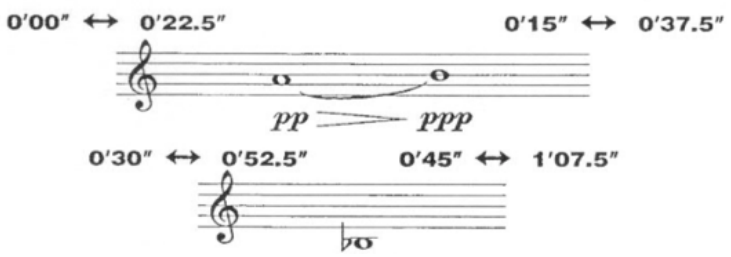


Figure 6.5.1 *Flexible time brackets in* Four *— Part 1, Section A*

Occasional *fixed* time brackets specify a set duration that *must* be sounded by the entire ensemble (Figure 6.5.2).

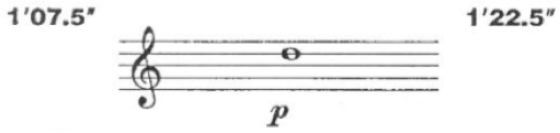


Figure 6.5.2 *A fixed time bracket:* Four *— Part 4, Section A*

The placement of notated material within each time bracket is at the discretion of the players, and can be determined either by system or constraint, or left open and decided in-performance (the approach taken by the Bozzini Quartet in Appendix A, Track 5).

Surface Consonance and Potential Harmony

Pitch material in *Four* is expressed in Common Practice Pitch Notation, having been derived using Andrew Culver's bespoke *ic* software, which selects pitches by chance operation from input lists comprised of letter names (Weisser, 2003: 197). Notwithstanding this chance-based pitch derivation, *Four* is characterised by a notably consonant harmonic surface, rich in tuneable intervals, of which Benedict Weisser remarks:

> …there is no evidence of [Cage] hard-wiring any special formula into the [*ic*] programme in order to produce a bias toward familiar vertical relationships. One could also credit this sonic imprint to total dynamic and timbral homogeneity; the work is never louder than P, and it consists exclusively of long tones played non-vibrato. However, there comes a point where such explanations proved inadequate in accounting for the presence of what sounds like triadic

> harmony. It is so striking and, in fact, that the listener knowledgeable of Cage's music feel the need to negate it, to view it as a kind of illusion verisimilitude. (Weisser, 2003: 201)

In the presence of potentially consonant pitch clusters, as exemplified in Figure 6.5.3, ensembles must decide whether to approach these pitches as constituting triads and seventh chords—and therefore to tune each pitched sound as a component in a relational whole—or to disassociate conventional groupings and to approach the intonation of each pitched sound through other means.

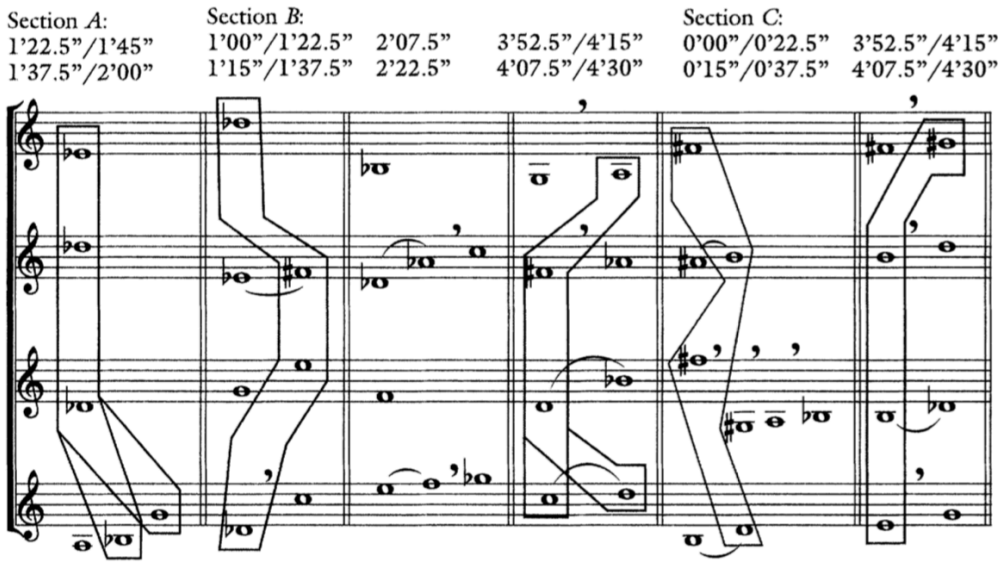


Figure 6.5.3 *Possible Triads/Seventh Chords in* Four *(Weisser, 2003: 203)*

As Weisser observes, Cage's noted and active disinterest in harmony throughout much of his practice and oeuvre preceding the Number Pieces might lead some practitioners to reject a relational approach to pitch in *Four* and, as a composer colleague once advocated during one of my early research presentations on this work, instead treat notated pitches as 'sonic objects' rather than as harmonic components. My response to this colleague on that day was to ask the same question I hope to answer through this research: how might I structure a practice of intonation in this piece? If not by relational technique, then by what *other* technique might I structure my practice? For me, a string player, there is no pitched sound without intonation technique.

In the absence of any superimposed tuning system, creative constraint or guiding principle of intonation technique, it is probable that a quartet of players relying solely on intuition (and finely-honed aural skill) would hear the surface consonance observed by Weisser and be drawn toward

'good' tunings of what sound like recognisable intervals. A decision to the contrary would almost certainly be made deliberately, as it would render more complex intervals with less overall consonance, and may indeed carry further implications in public presentation (i.e., *why are those triads so out of tune?).* Naturally, a decision not to conform to low-order consonance would not be *wrong*—and indeed such a realisation may be formulated through processes that align acutely with Cage's compositional ethos (for instance, if a tuning schema were to be developed through chance-based procedures).

My interest in developing a practice of intonation based on low-order ratios (deriving intervals substantially from 5- and 7-limit JI) is reflective of my own artistic curiosities about the creative constraints afforded by such a practice. This approach is, however, not unsupported by Cage's own perspectives on harmony in this period of his compositional practice. Upon encountering the work of James Tenney—in particular his extended JI work *Critical Band* (1988)—as well as the *Deep Listening* practice of Pauline Oliveros, Cage commented, 'if this is harmony, I take back everything I've said—I'm all for it' (Revill, 1992: 280). If this revelation does, as Weisser asserts, reflect Cage's 'reconciliation' with 'harmony and the possibility of some measure of retrievable vertical relationships' (Weisser, 2003: 199), then a practice of playing *Four* with attention to the perceived harmonic space is in no way antithetical to Cage's preoccupations as a listener at the time of composition. To quote from his *Mesosticha* (1990):

> now haRmony / has changEd / its nAture
> it comes back to you it has no laws /
> there is no alternative to it
> (Cage, 1991: 27)[8]

My experience of negotiating my own pitch material within the string quartet setting leads me to agree with Cage that there is no alternative to harmony in *Four.* To my composer colleague, whose preference for 'sonic objects' was by no means unconvincingly argued, I can only offer this reply: *I am tuning and therefore relationality is occurring.* The lines along which that relationality is determined can change between practices, but my technique by nature excludes an epistemology of intonation that is entirely non-relational.

[8] Text is quoted here excluding mesostic aligment (as in Weisser, 2003: 199).

Preference Rules

As an alternative to treating harmony in *Four* as functional—which I appreciate might arguably be antithetical to presiding arguments surrounding the practice of Cage's music—I propose that the establishment of some basic *preference rules* might enable a quartet to arrive at a group intonation technique that is both open enough to accommodate any of the harmonic eventualities potentiated by the open score structure, and still constrained enough to avoid the kind of intonation drift described in Skempton's *Tendrils* (6.3).

Preference rules are statements of intent that define, in the light of contextual factors and other preference rules, likely constraints or limits that can be applied to an analysis. Preference rules were adopted from Generative Linguistic Theory (e.g., Chomsky, cited in Lerdahl and Jackendoff, 1983), by music theorists Fred Lerdahl and Ray Jackendoff (1983: 5) in order to address the analysis of musical structures which, they argue, are 'not hierarchical'. Defining their theory as 'a description of the musical intuitions of a listener who is experienced in a musical idiom' (1983: 3), Lerdahl and Jackendoff acknowledge that any musical example is subject to any number of possible analyses. Preference rules can help a reader establish a contextually appropriate description of a musical event.

Preference rules are employed by Lerdahl and Jackendoff as tools for performing formal analyses of tonal music. However, as heuristics that can be established *pre-practice*, preference rules can help to streamline the decisions of a group of players, and define points of necessary constraint within a non-hierarchical harmonic space like that of *Four*. An example of some initial preference rules for one projected realisation, discussed below, are:

1. Prefer no vibrato on all material
2. Prefer the intonation of simultaneous pitch relationships over successive pitch relationships
3. Prefer low-order tunings up to 7-limit Just Intonation

Perceived References

In standard metric notation, the task of attending to relational intonation requires that players establish the reference pitch around which each simultaneity (or collection of pitch materials) is

tuned. In the case of consonant clusters like those in *Four*, a reference pitch is likely to be determined as the pitch with the greatest number of tuneable relationships to other pitches, although register and order of entries can influence this perception as well. Figure 6.5.4 shows potential consonant simultaneities present in the first time-bracket of Section A. The D-flat in Part 4 immediately presents itself as a potential reference pitch, as the pitch with which all other voices can form tuneable intervals: a perfect fourth (4/3) with A-flat, a minor third (6/5) with B-Flat, and an enharmonic spelling of a minor sixth (8/5) with A[9].

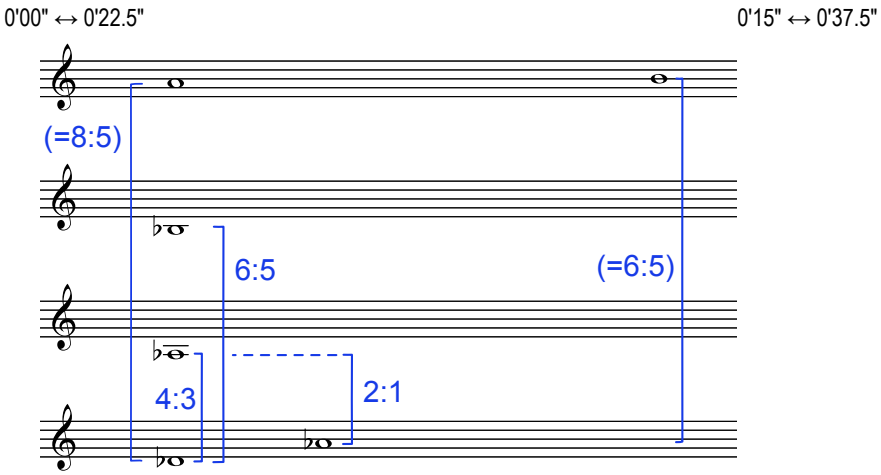


Figure 6.5.4 *Consonant simultaneities in Section A [0'00"–0'37.5"]*

Time brackets, in combination with Common Practice Pitch Notation, introduce a unique intonational challenge for string players. Within each time bracket, a variable ordering of voices stands to alter the perceived root among the pitches. A change in reference pitch can affect the intonation of relative pitches, as demonstrated in the differences between Figures 6.5.5 and 6.5.6:

[9] I acknowledge that such an enharmonic reading could be contested. However, due to the chance-based means by which this pitch material was derived, based on pitch class names fed into the *ic* generator and not on harmonic function, no intention can be read into the enharmonic content of the pitch material, i.e., D-flat does not carry an implicitly different function to C-sharp, as might be the case in some harmonic contexts or tuning systems. Equally, there is nothing in the score to suggest that pitch should be generalised in 12-EDO. Therefore, when *listening* to D-flat and A sounded together, the interval heard might be perceived to fall within the tolerance range of a minor sixth, regardless of its spelling as an augmented fifth.

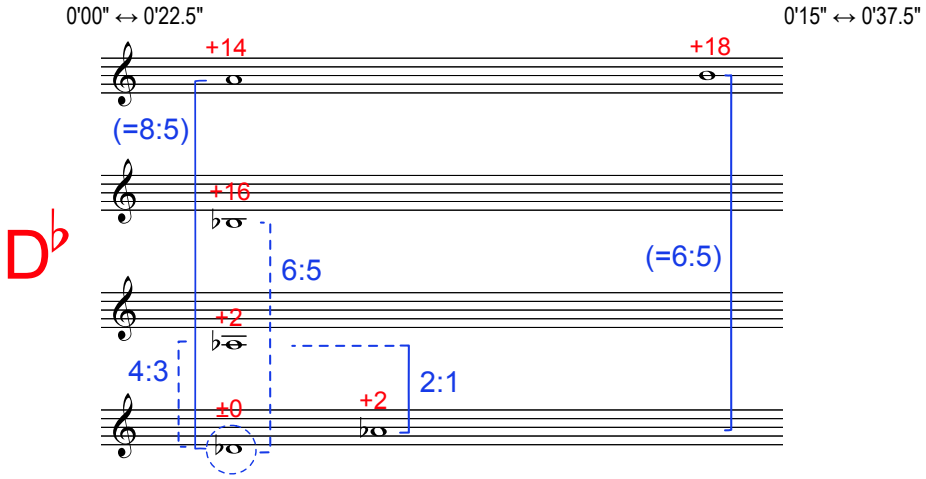


Figure 6.5.5 *Four, Section A [0'00"–0'37.5"] with D-flat reference pitch*

Furthermore, in the particular time bracket structure utilised in *Four*, the seven seconds of overlap at the extremities of most time brackets mean that any of the material from one time bracket may be carried over into the next. This feature of the notation not only increases the number of possible pitch relationships within those seven seconds, but also has ramifications for the pitch relationship in the following time bracket.

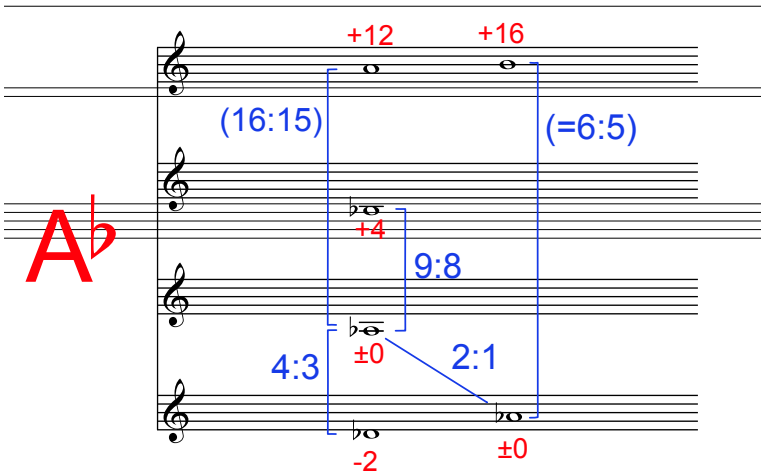


Figure 6.5.6 Four, *Section A [0'00"–0'37.5"] with A-flat reference pitch*

Fig. 6.5.6 projects a reading of the first two time brackets in Section A, in which the *lowest* voice (A-flat in Part 3) is taken as the reference pitch by the other players. Part 4 might establish a perfect fourth (D-flat, 4/3), and Part 2 a Major second (B-flat, 9/8). An enharmonic reading of Part 1 allows the A to be treated as a minor sixth (8/5) on the D-flat in Part 4. If this material were

isolated, it could easily satisfy the preference rules set out, however, an overlap between time index 0’37.5" and 0’30" in the subsequent time bracket introduces the possibility of additional pitch relationships.

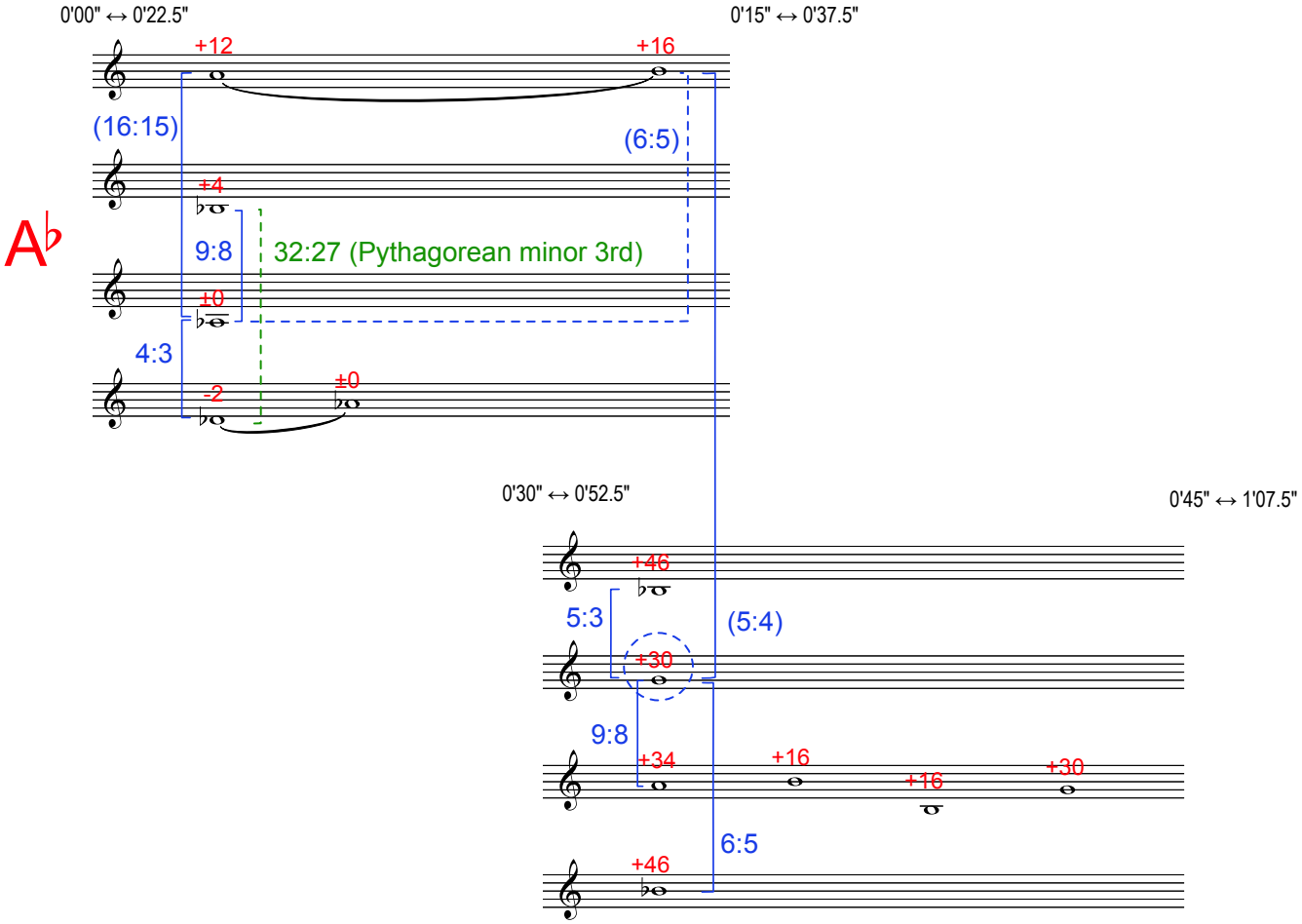


Figure 6.5.7 Four, *Section A [0’00"–1’07.5"] with A-flat reference pitch*

Having tuned all the pitch material in the first time-bracket on the A-flat reference pitch, any overlap would oblige the ensemble to carry that A-flat root into the tuning of the next time bracket. If, during the overlap, a simultaneity was to occur between Part 1 (time bracket 1, B) and Part 2 (time bracket 2, G), the resulting major third (5/4) would push the intonation of the G to +30 cents. Subsequent entries would then take this as the new reference pitch—constituting a substantial micro-harmonic modulation, nearly a sixth-of-a-tone sharp in relation to their open strings.

While there is nothing musically or methodologically prohibitive about this eventuality, several instrumental and/or technical factors make it impractical as an overall intonation strategy. First, A-flat is not an ideal root on which to tune the pitch collection in the second-time bracket, as most of the pitches relate to A-flat by a semitone—an interval which for me is not always reliably tuneable. Second, pitches begin to sit awkwardly relative to the open strings, meaning that stopped alternatives will have to be used—as seen in Part 3, with the A+34—and this will necessarily affect the overall sound profile of the ensemble.

Furthermore, overlaps in the course of further time brackets would likely result in a chain of low-order tunings which, as illustrated in Skempton's *Tendrils* (6.3), could easily result in far greater micro-harmonic modulation. Irreconcilable difficulty may arise if the intonation of notated pitches were to drift perhaps more than one third of a tone (around ±66 cents) away from the instrumental pitch centre. This anomaly illustrates the inherent impracticality of a purely relational, chain-based JI practice in indeterminate harmonic environments, and suggests that some further measures of constraint could benefit players choosing to explore such a practice.

One option, drawing on strategies explored in Section 6.3, is to add a simple yet fundamental preference rule for open strings and equivalent intonations, as this will limit the number of potential reference pitches by providing four centres of intonational 'gravity' related through a string-friendly Pythagorean pitch space. Figure 6.5.8 projects a reading of the same two time brackets, this time taking G (-4, in keeping with the violin's Pythagorean intonation) as the common reference pitch for both time brackets. In the first time bracket, G is an *un-stated* reference pitch which nonetheless relates clearly to the pitch content in Part 1, from which other tuneable intervals can then be derived. Upon the arrival of the second time bracket, a sustained G reference pitch enables pitch material to arrive in any order while retaining an overall pitch centre that is negotiable within the material impositions of the instruments.

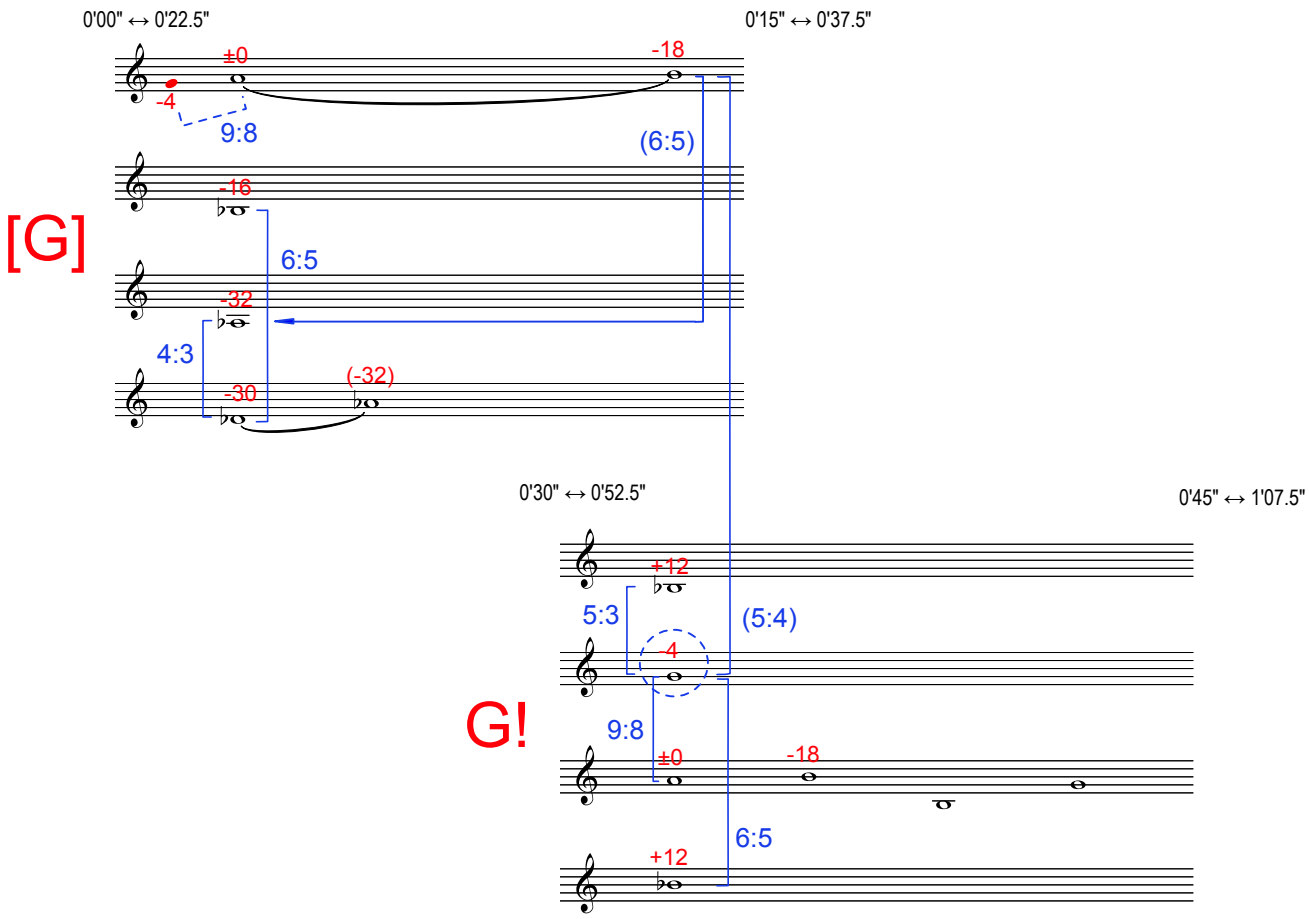


Figure 6.5.8 Four*, Section A [0'00"–1'07.5"] with G reference pitch*

By retaining this stable reference between adjacent brackets, the ensemble can confidently predict any of the possible relationships which may occur in the open structure. A revised list of preference rules for this practice, then, might be:

1. Prefer no vibrato on all material
2. Prefer open strings and equivalent intonations
3. Prefer simultaneous over successive pitch relationships
4. Prefer low-order tunings up to 7-limit Just Intonation

Reflecting on prior practice

In common with my reflections on the Bozzini Quartet's recording of Skempton's *Tendrils* (6.3), our realisation of *Four* is not directly represented by the above exploratory score annotations. It

does, however, give evidence of a practice in which similar patterns of intonation technique are foregrounded.

The Bozzinis' approach to intonation is difficult to summarise because it has been developed across years of practice. Their distinctive sound—characterised by an overall absence of vibrato, an attention to the intonation of simultaneities, and a concern for tuning as an integral aspect in crafting sonority—has been arrived at through the practice of repertoire that foregrounds and reinforces these qualities. Score annotation, as employed in my own discussions, was not a primary feature of the group's working methodology (although individuals may indeed have employed their own systems of annotation). However, rehearsals were often characterised by comments like, 'no, your G has to be a third there,' or 'this one is an A cluster'.

In expanding on this practice in my own research, my aim is neither to restate its virtues (which I believe speak for themselves) nor to query any of its methods. My focus is the refinement my own technique, and the consideration of how this learning may be impactful in my wider practice of playing and teaching.

One way these exploratory analyses have informed my technique is that they have given me a clearer picture of why certain pitches or harmonic spaces were always challenging to negotiate in our quartet's practice of *Four.* In our recording, the placement of pitch material within each time bracket was left to the discretion of each player in the moment. While I cannot speak for my colleagues, my own decisions were sometimes motivated by cautiousness or uncertainty about intervals that might result—that is to say, I sometimes waited to hear another player's entrance before placing an ambiguous pitch in relationship.

Given the limited amount of pitch material in *Four*, I am convinced that an analysis of shared reference pitches and the subsequent relationships formed by component pitches within each time bracket would be both practical and constructive. In practising relational intonation in the context of indeterminate harmonies, such a process would give me greater confidence in the audiation of my own pitch materials, both in intuitive placements, as well as in structured systems.

What I carry forward

As discussed in Section 6.1 (*Slip Minuet*), one benefit of superimposing a tuning system on a reading of Common Practice Pitch Notation is in the potential to filter some of the learned

responses and received practices that can accumulate in technique. The projection of a 7-limit JI harmonic space helps me to imagine a practice of intonation characterized by high degree of harmonic consonance. In developing this practice, however, I can foresee how similar patterns of intonation technique might be directed toward entirely different renderings.

Taking up earlier speculation about practices of intonation that do *not* foreground low-order consonance, but which retain a fundamentally relational intonation technique, preference rules again furnish creative constraints. For example:

1. Prefer no vibrato on all material
2. Prefer the *nearest open string* as a reference pitch
3. Prefer low-order tunings up to 7-limit Just Intonation

This set of preference rules differs from my previous set on only one point (2.) and yet results in a profoundly different collection of pitches:

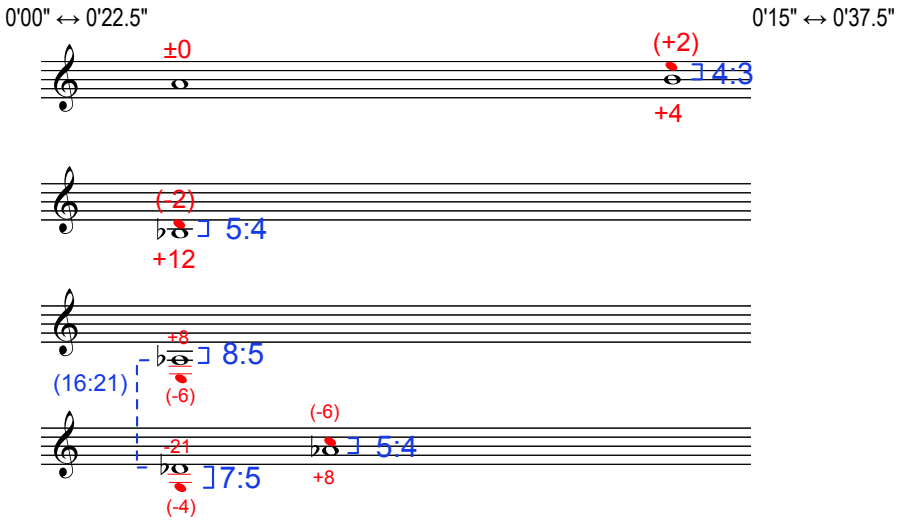


Figure 6.5.9 Four*, Section A [0'00"–0'37.5"] with independent open-string references*

Here, each pitch forms a tuneable interval with a nearby open string (or octave equivalent), while the *resultant* intervals formed by the sounding pitches may be *untuneable.* For example, in Parts 3 and 4 (Figure 6.5.9), A-flat (+8) and D-flat (-21) form a fourth that is approximately 30 cents narrow of the just fourth (4/3), resulting in what is (for me) an untuneable frequency ratio of 21/16.

The pattern of intonation technique projected here is, in fact, largely unchanged from those discussed throughout this section, and indeed from that exemplified in my discussion of *Tendrils* (6.3). In all cases, the instrumental intonation in fifths is utilised to provide stable references on which tuneable harmonies can be built. The difference here is that references are taken independently by each player, rather than as a collective, and the resultant harmonic landscape thus gains many degrees of complexity.

Where this reflection on *Four* contributes substantially to this research is in giving clear evidence of how one pattern of intonation technique can structure vastly different realisations, in which opposing sonic signifiers may mask the presence of shared technical pathways. This insight will be further explored in the following section (6.6).

6.6 Scott Mc Laughlin: *The endless mobility of listening* (2016)

Scott Mc Laughlin composed *The endless mobility of listening* for me in 2016 as a part of a collaborative research and creation project, supported by the Britten Pears Foundation (UK). This portfolio submission (Appendix A, Track 6) was recorded by Scott Mc Laughlin and Pete Furniss at the Stanley Glasser Electronic Music Studios, Goldsmiths, University of London (UK) in December 2018, for planned release in 2020 (label to be confirmed).

The piece can be played in part or in full, giving a variable duration; this realisation of the complete score lasts approximately 70 minutes. Three procedural elements cycle throughout, determining the duration, pacing and form of each realisation: *Tuning* (omitted from studio version)*, Seeking/Capturing* [eg., 1:10, 21:08]*,* and *Chorales* [eg., 4:37; 9:45; 19:14]. These procedures are discussed as they elicit patterns of intonation technique relevant to the negotiation of material agency and contingency in the harmonic spectra of extreme *scordaturas*, and the externalising of integral, internal processes by live electronic infrastructure.

‘Drone Bowing’

The majority of sonic material in this piece is generated through ‘drone bowing’—a method of activating the harmonic spectra of open strings through subtle changes in bow pressure, angle and position, as described by Mc Laughlin (2017):

> I found that slow and gentle drone bowing *sul pont* on open strings allows the string fundamental to collapse and reveal instead one or more higher partials… The string spectrum moves from being whole (single percept of the fundamental) to something more bell-like where partials become audible as objects in themselves, often subtly shifting and overlaid against each other, fluctuating between single and multiple percepts.

The left-hand fingers are largely inactive throughout *Endless…*, except in the short Chorale sections which demarcate the end of each section, and explicitly connect the harmonic identities of adjacent fundamentals (i.e., the next open string to be bowed). The drone bowing technique was developed by Mc Laughlin across several collaborative projects in which I took part, beginning in 2012 with his string quartet *A metastable harmony* (see Mc Laughlin, 2017) and following on with *Endless…* (2015–16).

(re)Tuning

Each of the 14 cycles (tuning, seeking/capturing, chorale) in *Endless…* takes a different open-string *scordatura* as the basis for new harmonic content. In live realisations, strings are re-tuned in real time at the end of each section—although this process is omitted in the studio recording.[10] The tuning schematic of each string relates to a common anchor pitch—B5 (-14), the fifth partial of G—which appears as a different partial in each new scordatura, as described in Figure 6.6.1. In each section, this B will be potentially present, but may be more or less likely to emerge from the drone, depending on various material or environmental factors, discussed below.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Str. II					A 9°				G 5°			F+36 11°		E-16 3°
III			C#+23 7°				C-2 15°			B-14 2°				
IV	G 5°	F+36 11°		E-16 3°		D+45 13°		C#+23 7°			C-2 15°		B-14 2°	

Figure 6.6.1 *Tuning structure of* Endless…

[10] In a live performance, retuning is a discrete event, carried out at a low volume so as to remain embedded in the overall harmonic blanket of the drone. This blend is possible because the violin output is mixed at a similar output level as the electronics, so I can control my instrumental volume much as I would in an acoustic performance. I use a chromatic tuner with a clip pickup (attached to one of my tuning pegs) to tune pitches accurately, without having to hear precise proportions. For the recording, however, the violin feed was taken directly from a DPA4060 microphone, attached behind the bridge, while the electronics were subsequently rendered in the studio. Scott decided to drop my tuning out of the final mix, rather than adjust my levels in post-production, or leave the tuning process too present in the mix.

Seeking and Capturing

Beginning by bowing an open string at a neutral sounding point, I allow the contact point of my bow on the string to drift toward *sul ponticello*, exploring various angles and degrees of pressure, until clear partials begin to surface amidst the convoluted bow noise. The objective of the *Seeking* process, in Mc Laughlin's words (2016), is to 'allow partials to emerge from the string sound'. The score directs me to

> [u]se subtle changes to bow position/angle/speed/pressure/etc. to coax—but [not] force—partials out into prominence… Seek the B-14c partial, but allow any others to come out. Be generous, afford revelation. (Mc Laughlin, 2016)

The B5 anchor partial is retained in my attention; however, my objective is not necessarily to sound this pitch, but rather, as Mc Laughlin (2017) explains,

> to use the B5 as a distant point to aim for, a *structuring intention* [my emphasis]. Knowing that any partial that emerges confidently is a worthy addition to the piece, but that any emergent partial will have some distant or close relationship to the B5, and this emerging network of relationships structures the piece.

Figure 6.6.2 *The structure of* Endless… *(Mc Laughlin, 2019)*

As stable partials emerge, I can choose to *capture* these pitches using a bespoke looping patch (Figures 6.6.3, 6.6.4), which then sustains and adds the captured material to the continuous looping electronics. Material which is generated as a response to the sounding environment is then integrated into a constantly thickening harmonic texture, and becomes the impetus for new responses (as represented in Figure 6.6.2). Looped material remains sounding throughout the piece, however older samples are progressively reduced (made less frequent) in the mix after fifty captures, effecting a gradual unfolding of harmonic texture across the duration of a performance.

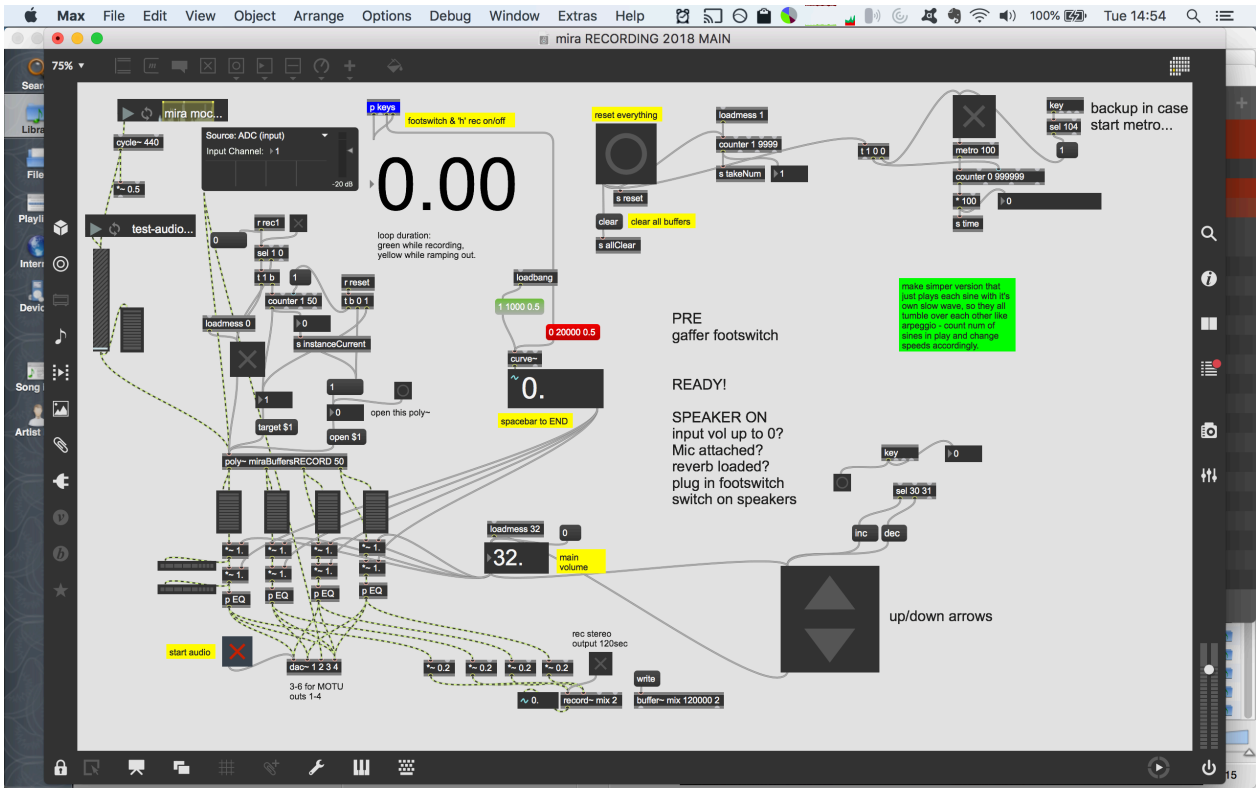


Figure 6.6.3 *Looping patch (Mc Laughlin) for* Endless…

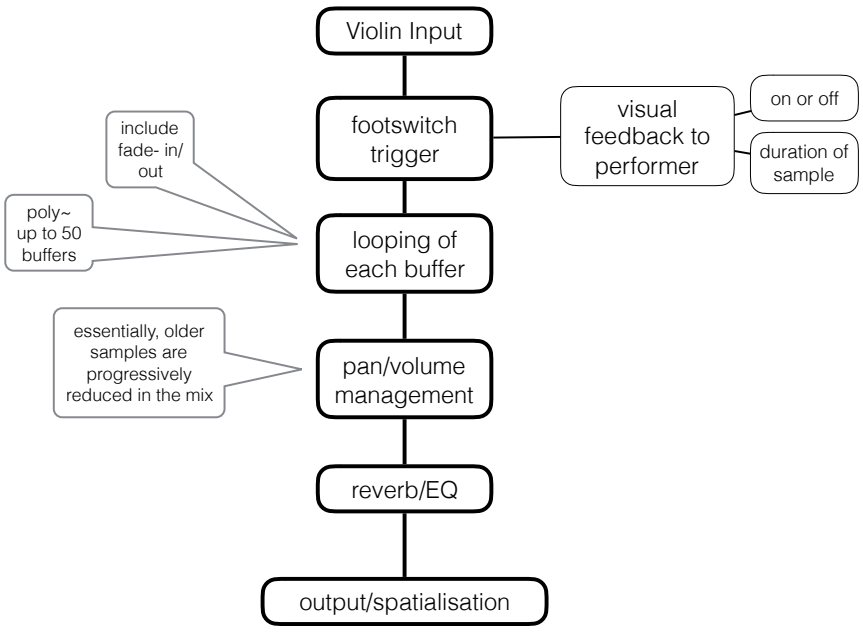


Figure 6.6.4 *From violin input to spatialized output (Mc Laughlin, 2019)*

Contingency and Material Agency

Many of my conversations with Mc Laughlin during the Research and Creation phase of this collaboration centred around the relationship between my own enactive body's exercising of agency (technique) over the instrument, and the violin as itself a resonant body exhibiting its own material agency. Referencing Ingold's (2013) discussion of *materiality*, Mc Laughlin (2017) reflects:

> in this piece Mira works 'with' the string, its material predilections, to encourage material agency. […] …a B partial is always possible, but at different levels of likelihood.

Mc Laughlin's tuning framework, in coming together with the material agency of my instrument, affords certain pressures on my technique. At any point of decision making I may:

1) hear the B (-14) partial, choose to capture it, and manage to
2) hear the B (-14) partial, choose to capture it, but not manage to, and instead something else emerges
3) hear the B (-14) partial but decide I want to hear something else, so continue seeking
4) not hear the B (-14) partial but like what I do hear, so choose to capture that, and manage to
5) not hear the B (-14) partial but like what I do hear, so choose to capture that, but not manage to, and instead something else emerges
6) not hear the B (-14) partial and not like what I do hear, so continue seeking

The seeking and capturing of pitches are to some degree exercises of *choice*, and at the same time these choices are not entirely within my control. At any point in any of these above processes, my instrument may behave unpredictably, placing me in a position of negotiating contingency—whether to continue with an active process, or allow myself to be diverted toward a new process, suggested by the material preferences of the violin. Mc Laughlin reflects that this persistent sense of contingency in *Endless…* sets the practice 'against a paradigm of control' (S. Mc Laughlin, personal correspondence, 16 December 2018[11]), noting that

[11] All comments cited from Mc Laughlin (2018) are taken from an interview conducted 16 December 2018 in London.

> rather than trying to 'get' anything, your job is to support what the instrument wants to do. This creates a levelling of agencies… you bow, hear something trying to emerge, adapt technique to accommodate that, let it come out, support it in coming out.

In the same vein, I can push back against the instrument's material tendencies and decide, for example, that I am tired of hearing certain strong partials and instead support *other* aggregates to emerge. Such a choice remains rooted in a fundamentally *supportive* perspective toward the instrument (Mc Laughlin, 2018); in seeking something other than what I am hearing, I am acknowledging that there are components in the sound that I am not hearing, and choosing to support them over what is sounding. The seeking/capturing process leaves in its wake an emergent topology of this dynamic, between my choices (how I responded, what I prioritised, what I sought) and the material agency of the instrument—a process Mc Laughlin has likened to a 'long-exposure image' (S. Mc Laughlin, personal correspondence, 7 March 2016).

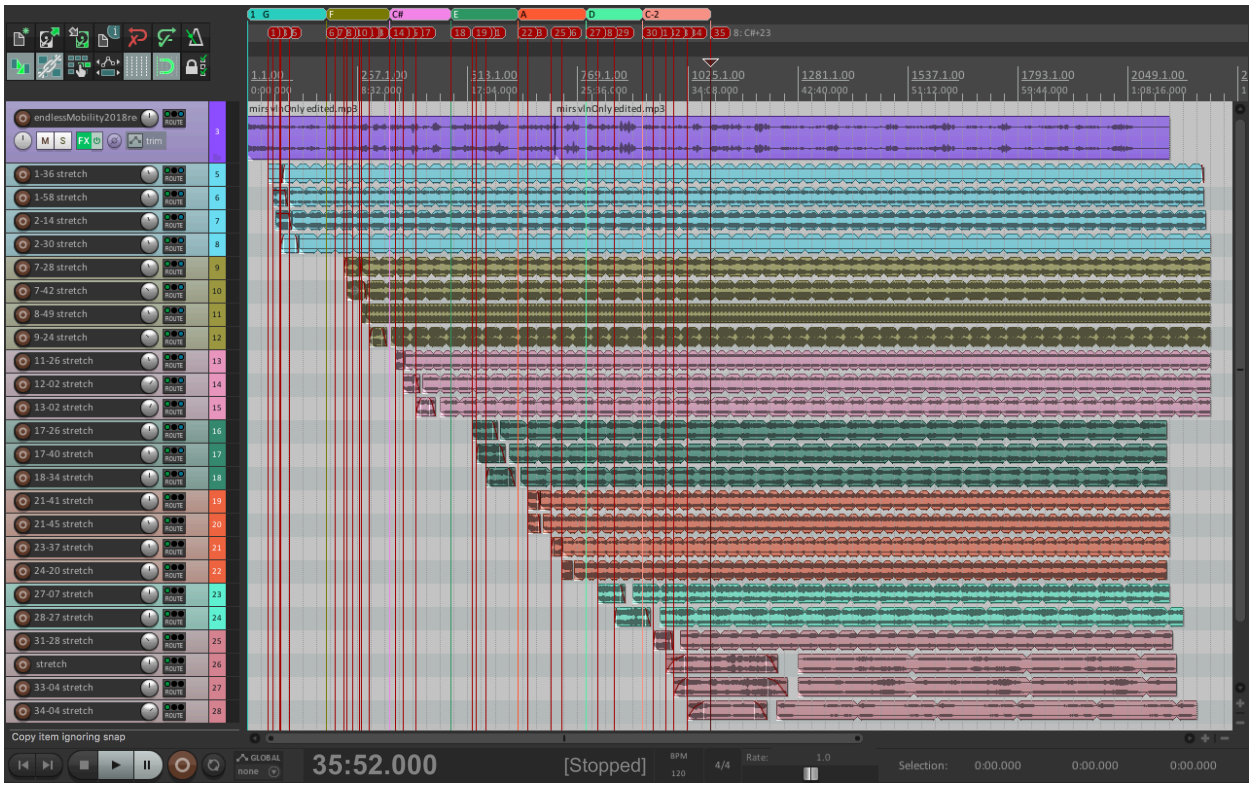


Figure 6.6.5 *Layering of captures in the recording of* Endless…

Is this intonation technique? (What I carry forward)

In recent reflections on studio-based Practice Research, media scholar Kim Vincs (2007: 112) reflects on the 'profound epistemological disjunctions that can occur between artworks of seemingly similar aesthetic, genre, and content', upon which musicologist Lauren Redhead (2019) has elaborated that questions of 'genre, form and content do not guarantee a path of knowledge'. By the same token, dissimilarities in these areas, which might set *Endless…* apart from the other pieces examined in this portfolio, stand to mask profound epistemological *conjunctions* that connect all these practices through embodied technique.

The ready observability of left-hand fingering can lend disproportional emphasis to this component of intonation technique, as demonstrated by many practitioners in Chapter 4. In the five works which precede *Endless…* in this portfolio, left-hand fingering occupies a spectrum from implicit to prescribed action, but nonetheless plays a focal role in defining the patterns of intonation technique present, as well as the outward signifiers (sonic and symbolic) of the practice. In the absence of any left-hand fingering with which to control pitch, *Endless…* serves to reframe intonation technique, placing emphasis on *recognising* tuning patterns and allowing them to emerge. The drone aesthetic and extended duration arise when integral observational and reflective components of technique are *externalised* and *foregrounded* by the live looping patch. These integral components of intonation technique thus become the main carriers of content.

In this respect, *Endless…* represents another logical conclusion of this research. Like *Windfell* (6.4), this is a piece about participating in a relational dynamic of intonation through a sustained and rigorous practice of listening. Where the epistemic objects of *Windfell* are primarily manifested for me internally, as embodied processes, these processes are made observable through the infrastructure of *Endless…*, enabling me to interact on an explicit, relational level with my own intonation technique. That interaction can result in new *ruptures* (to draw on Schwab's terminology) from which further embodied knowledge can emerge. My practice of *Endless…* carries my engagement with intonation from what Karin Knorr Cetina calls 'habitual' to 'objectual' practice—in which 'objects of knowledge appear to have the capacity to unfold indefinitely'. Such a practice is 'always in the process of being materially defined' and thus its epistemic objects 'continually acquire new properties and change the ones they have' (Knorr Cetina, 2001: 181).

7. Instances of Practice II: Teaching 'Advanced Intonation for Strings'

The epistemology of embodied practice explored in this thesis has led me to view creative outputs as instances where technique is put to use—an outlook which levels potential hierarchies between moments of practice and encourages an approach motivated by an 'epistemic impulse' (Spatz, 2015: 218). The previous chapter demonstrated six examples of practice structured by intonation technique, from which new technical insights have emerged that may be carried into my future practices of violin playing.

As this research period has progressed, my creative focus has become increasingly concerned with sharing this knowledge with other learners, in large part due to my engagement as a visiting lecturer at the University of Leeds (documented below) and my subsequent appointment as Lecturer in Performance at Goldsmiths, University of London. I have come to view teaching, like playing, as giving instances of practice, which draw on many common components of embodied technique.

This chapter documents and discusses an original module for undergraduate string ensemble players—*Advanced Intonation for Strings*[1]—the focus of which is to present intonation technique and microtonal notation in an ensemble performance context. The module was written concurrently with its delivery at the University of Leeds, between January and April 2017. This material thus represents, first, evidence of a unique, discovery-led practice of teaching a specific group of students in UK higher education, and second, a considered pedagogical tool which can be adapted for future use.

7.1 Methods

The methods related here draw from my experience of teaching this module during the winter of 2017 at the University of Leeds. While my own teaching strategies and experiences are heavily referenced in presenting the material, this chapter is not intended as an exposition on classroom

[1] Having completed this research, I would remove the word 'Advanced' from the module name in any future iterations, as it now seems to me inherently biased toward just the kind of hierarchical, goal-oriented learning which this module aims to circumvent.

pedagogy. Rather, this material is proposed as anecdotal evidence of the practical concerns of this specific group of performance students, and of how my research was able to address those concerns. Based on my experience of teaching at the undergraduate level over ten years, as well as relevant literature reviewed in Chapter 4 of this thesis, I consider the attitudes toward pitch and intonation held by these students prior to the start of this module to be representative of those held by many classically trained string players. The pedagogical approach taken here is, then, generally applicable to string players at the undergraduate level.

My initial goal[2] for the course was to encourage students to answer the question: *how can understanding microtonal models of pitch space inform and enrich our technique of intonation, and vice versa?* The teaching strategy used in designing this module employs and adapts methods commonly used in foreign language teaching. EFL[3] pedagogue Jeremy Harmer describes how

> [language teaching] recognises the value of [exposure to material] through comprehensible input, while still believing that most people… find chances to concentrate on [material forms] and how they can be used extremely helpful. (Harmer, 2007: 51)

The module follows the *Engage–Study–Activate (ESA)* teaching schema, outlined in Harmer's book *How to Teach English* (2007). In the ESA model, teaching sequences are structured by three stages or elements, which create a shape for the learning experience.

The *Engage* element provides impetus for the students to question their existent knowledge about the subject matter, and gives them agency by making these questions the focus of the learning. The *Study* element employs *discovery activities* (Harmer, 2007: 272)—examples or tasks that enable learners to discover answers to their questions through active participation. The *Activate* element furnishes carefully curated frameworks in which students may exercise newly learned material, encouraging them to make mistakes, test the boundaries of their knowledge, and receive feedback from the teacher and their peers. Crucially, each element of the ESA model contributes to the learner's developing awareness and context surrounding their own knowledge—and it is this process, rather than any prescribed outcome, which is prioritised in the teaching. In this regard, ESA teaching stands in contrast to many of the approaches taken in conventional performance pedagogy.

[2] As elaborated upon in the introduction to this thesis, pp. 19–23.
[3] English as a Foreign Language

Repertoire studied across the module was presented as material through which technique might be established and self-driven practice might be explored. A student's relative proficiency with a given technique was therefore considered less significant than the depth of their critical engagement with that technique, as a component of their personal knowledge resource. For example, while one Learning Objective of the module was to develop technique for sounding natural harmonics, the students were encouraged to regard a harmonic that sounded readily with equal scrutiny as they might one that 'cracked'. Both were regarded as affording valid information which would enable the students to understand the boundaries and thresholds of that technique. In keeping with this attitude, the students were offered repertoire that accommodated both sonic outcomes.

The term *practice*, as used throughout this research, proved initially challenging for the students, as its foregrounding of process and experience stood in contrast to other more outcome-oriented activities they associated with that word. On this point, historian Mary Carruthers's discussion of the apprenticeship education model proved helpful, as she describes how practice can be understood 'both in the sense of being "preparation" … and in the sense of "working in a particular way"' (Carruthers, 1998: 2). Activities were thus presented to the students as *giving practice of* a specific technique or concept—a phrase chosen to convey the work we were doing *as practice* (the instantiation of technique), as well as the necessity *to practice* (in the sense more familiar to the students, implying rehearsal).

7.2 Materials

Teaching materials for this module can be grouped into three categories:

1) handouts containing contextual and applied material (Appendix B)
2) musical scores (Appendix D)
3) video tutorials (Appendix C)

Original contextual and applied materials were created to guide the students toward specific *Learning Objectives* (theoretical or contextual knowledge relevant to specific technique) and *Technical Objectives* (areas of technique foregrounded in the week's activities). Many of these

materials were adapted from Christine Heman's book *Intonation auf Streichinstrumenten* (1981)[4], which I found particularly well-suited to the ESA teaching schema because Heman formats her own contextual and applied materials as practical exercises.

Of the musical scores studied, three were selected from within my own repertoire because they provided a clear focus for particular Technical Objectives, while the remaining two were commissioned specifically as pedagogical works for the module. Each score promoted attention to and *gave practice of* a certain pattern or area of intonation technique.

Isaiah Ceccarelli's *Bow* encouraged judicious placement of frequency within the context of familiar intervals, and gave practice of hearing and sounding low-order ratios—corresponding to patterns of intonation technique explored in *Slip Minuet* (6.1). Linda Catlin Smith's *Orient Point* encouraged active decision-making with regard to the intonation of intervals (both simultaneous and successive), and gave practice of deliberate decision-making in ambiguous tuning contexts—corresponding to patterns of intonation technique explored in *Tendrils* (6.3). Taylor Brook's *Ptolemy's Observation* was commissioned for this module, and gave practice of reading, hearing and sounding rudimentary Just Intonation notation (cents and ratios)—corresponding to patterns of intonation technique explored in *Windfell* (6.4). Pauline Oliveros' *Out of the Dark* encouraged an exploration of active listening and the aural imagination, and gave practice of pitch-matching, slow pitch deviation, acoustic beating, and pitch-focused improvisation. Scott Mc Laughlin's *Threads of the Social* was commissioned for this module, and gave practice of sounding and improvising with the harmonic series, and of instrumental *scordatura*. Both of these works featured to patterns of intonation technique explored in *The endless mobility of listening* (6.6).

Video tutorials functioned primarily as supplementary study resources for the students, and were also used on occasion as preparatory *Engage* elements to be watched before the weekly sessions. They were prepared on a week-to-week basis, and often addressed specific questions that had arisen in class. As such, the video materials included in Appendix C provide documentary evidence of subject matter addressed during this particular iteration of the module. The videos are informal, in keeping with the colloquial tenor in which the module was delivered. They would necessarily be re-made upon any future iteration of the module, in order to address the unique learning needs of the participating students.

[4] As discussed in Chapter 4, pp. 91–94.

7.3 Weekly Lesson Plan

The lesson plan for the module, as taught at Leeds, comprises a weekly teacher-led lecture/workshop (two hours), and an additional weekly self-directed rehearsal (two hours) in which material from the group session is revised independently by small groups of students. In Leeds, the module concluded with a public performance of the aforementioned five contemporary pieces for string orchestra.

The following weekly lesson plan, adapted from Harmer (2007: 161), outlines in detail the Learning and Technical Objectives, teaching materials and activities covered in each of the ten teacher-led lecture/workshop sessions. Each session addresses one aspect of intonation technique in detail. For each teaching activity *aims* are defined, as well as how the activity fits into the ESA framework. *Interaction patterns* track the proportion of time spent in teacher-led activities, in comparison to time spent in group-participation or student-led activities. A greater proportion of time should ideally be spent on the latter.

Week 1: The Glissando Continuum

Aims: To introduce concepts of *tuning practice* and *intonation technique.*

Learning Objectives: To introduce musical pitch as a continuum; to introduce and give practice of *relational* intonation.

Technical Objectives: To introduce and give practice of active listening as a component of intonation technique; to give practice of hearing and recognising acoustic beating and difference tones; to give practice of slow bowing technique; to give practice of slow glissando technique.

Materials: Handout 1; Score: Pauline Oliveros – *Out of the Dark*; Supplementary Video: 'Beats' (Bozeman Science, 2015); Supplementary Video: 'Beat Frequency' (Kahn Academy, 2016)

ESA Lesson Plan (Week 1):

Stage (E/S/A)	Time	Activity	Aim	Interaction Pattern
E	40 mins	Mind-mapping exercise	To challenge students' preconceptions about intonation & microtonality; to explore these topics through reflecting on lived experience	Workshop: teacher-led, group participation
S	60 mins	Exercises, Handout 1	To facilitate embodied discovery of key characteristics of string intonation; to refine perception of 'accuracy' in pitch matching & interval placement	Student-led small groups, teacher-supervised
A	20 mins	Group reading of Oliveros score: sections 1-4	To introduce Pauline Oliveros' score; to apply Learning & Technical Objectives in a musical context	Rehearsal: group participation, teacher-supervised

Week 2: The Harmonic Series

Aims: To present and give practice of hearing and sounding the harmonic series.

Learning Objectives: To introduce the harmonic series; to introduce low-order ratios as models for familiar intervals.

Technical Objectives: To give practice of playing harmonics 1-9 on open string fundamentals; to give practice using harmonics to realise and recognise low-order intervals.

Materials: Handouts 2, 3; Video Tutorials 1, 2; Score: Scott Mc Laughlin – *Threads of the Social*; Score: Pauline Oliveros – *Out of the Dark*

ESA Lesson Plan (Week 2):

Stage (E/S/A)	Time	Procedure	Aim	Interaction Pattern
E	Pre-class video prep. tutorial	Prep work: watch Tutorial Videos 1 & 2	To familiarise students with Harmonic Series, its physics & mechanics on string instruments	Student private prep.
S	20 mins	Volunteers & group: experiment with playing harmonic series (Handout 2)	To establish technique of playing harmonics; to begin recognising the sound of the harmonic series, and locating partials within it	Small student groups playing, teacher-supervised
S	10 mins	Discussion of Handout 3	To clarify how harmonics can be used to realise Just intervals	Teacher-led lecture
S	20 mins	Volunteers & group: experiment with using harmonics to form intervals	Embodied discovery and observation of intervals that can be realised between harmonics in the same series	Small student groups playing, teacher-supervised
S	10 mins	Introductory discussion of Just Intonation	To introduce the difference between Just intervals and tempered ones (as observed on the piano)	Teacher-led lecture
A	15 mins	Group reading of Oliveros score: section 5	To build on previous week's work by adding newly learned material	Rehearsal: group participation, teacher-supervised
A	45 mins	Group reading of Mc Laughlin score	To introduce Scott Mc Laughlin's score; to apply Learning & Technical Objectives in a musical context	Rehearsal: group participation, teacher-supervised

Week 3: Tuning Systems

Aims: To introduce the characteristics of (and key differences between) Just Intonation (JI), Pythagorean Intonation (PI), and 12-Equal Division of the Octave (12-EDO).

Learning Objectives: To introduce the construction of scales in JI, PI & 12-EDO; to present possible applications of JI, PI & 12-EDO in musical context.

Technical Objectives: To give practice of playing scale sections and intervals in relative systems (their feel & behaviour on the instrument).

Materials: Handouts 3, 4 & 5; Score: Isaiah Ceccarelli – *Bow*; Supplementary Handout: Melodic & Harmonic Intonation (Kimber, 2005b)

ESA Lesson Plan (Week 3):

Stage (E/S/A)	Time	Procedure	Aim	Interaction Pattern
E	15 mins	Review Just intervals formed by harmonics; eg. Perfect 5th (3:2) – compare PI vs 12-EDO; Question: are they the same?	To highlight the implications of *open-chain* vs *closed-chain* tuning systems; to encourage students to consider the impact of very small differences of pitch upon their practice of intonation (language used is still un-specific, eg. 'a little bit higher')	Teacher-led lecture
S	15 mins	Discussion of Handout 4	To present Pythagorean Major/minor Scale construction	Teacher-led lecture
S	15 mins	Group task: revisit Exercise 4 from Handout 1 (Week 1)	Embodied discovery of previously observed process, supported by newly learned, explicit terminology	Small student groups playing, teacher-supervised
S	10 mins	Discussion of Handout 5	To present the differences between tuning systems (using a common scale of measurement)	Teacher-led lecture
S	10 mins	Group task: revisit Exercise 7 from Handout 1 (Week 1)	Embodied discovery of potential application of different tuning systems in different musical contexts	Small student groups playing, teacher-supervised
S	10 mins	Discussion of *Simultaneous-Successive* Paradigm (Kimber Handout)	To present one common example of the use of different tuning systems in different contexts	Teacher-led lecture
A	45 mins	Group reading of Ceccarelli score	To introduce Isaiah Ceccarelli's score; to give practice of the potential application of JI/PI in a common practice pitch notation score	Rehearsal: teacher-led, group participation

Week 4: Cents and Ratios

Aims: To present and give practice of ratio and cent notations.

Learning Objectives: To introduce cent deviations as a means of modifying common practice pitch notation; to introduce cent measurements for common low-order ratios.

Technical Objectives: To give practice of reading cent deviations as components of ratio notation; to give practice of audiating Just intervals as expressed by ratio and cent notation.

Materials: Handouts 3, 4 & 5 (review); Video Tutorial 3; Taylor Brook – *Ptolemy's Observation* (Score)

ESA Lesson Plan (Week 4):

Stage (E/S/A)	Time	Procedure	Aim	Interaction Pattern
E	10 mins	Review of Ceccarelli score; Question: how might we describe the tuning choices we have made to a new member of the ensemble?	To elicit questioning about how decisions about/interpretations of intonation can be communicated and mutually understood	Discussion: group participation, teacher-led
S	20 mins	Review of Handouts 3, 4 & 5 with new discussion of Cents	To present cent deviation notation; to add a level of explicit vocabulary to previous modes of discussion (i.e. 'a little bit higher' becomes 'x cents higher')	Teacher-led lecture
S	15 mins	Group task: revisit Exercise 4 from Handout 1 (Week 1) with new discussion of Cents	Embodied discovery of previously observed process, supported by newly learned, explicit terminology	Small student groups playing, teacher-supervised
A	75 mins	Group reading of Brook score	To introduce the Brook score; to give practice of reading cent deviations and ratio notation	Rehearsal: teacher-led, group participation

Week 5: Playing with Low-Order Intervals

Aims: To present and give practice of low-order intervals.

Learning Objectives: To introduce the mechanics and sonorities of Just 5ths (3:2), 3rds (5:4) and 7ths (7:4); to discuss how these intervals can be expressed in notation.

Technical Objectives: To give practice of hearing and playing these intervals; to give practice of the potential challenges of using these intervals.

Materials: Video Tutorials 4, 5 (supplemental, post-session); Score: Taylor Brook – *Ptolemy's Observation*

ESA Lesson Plan (Week 5):

Stage (E/S/A)	Time	Procedure	Aim	Interaction Pattern
E	20 mins	Discussion of the mechanics and sonorities of Just intervals	To give practice of hearing and playing these intervals	Group discussion, teacher-led
S	40 mins	Sectional rehearsals, Brook	To allow each section to discuss patterns of intonation in their own parts	Student-led rehearsal & discussion, teacher-supervised
S/A	60 mins	Group rehearsal of Brook score	To present and give practice of hearing and playing the intervals involved in performing Brook's score	Group reading & discussion, teacher-led

Week 6: Making Decisions

Aims: To explore decision-making with intonation as a focus in an ensemble context.

Learning Objectives: To introduce the interpretive implications of decision-making in intonation practice.

Technical Objectives: To give practice of making choices about tuning in various contexts.

Materials: Video Tutorial 6; Score: Linda Catlin Smith – *Orient Point*; Score: Isaiah Ceccarelli – *Bow*

ESA Lesson Plan (Week 6):

Stage (E/S/A)	Time	Procedure	Aim	Interaction Pattern
E	Pre-class video prep. tutorial	Prep work: watch Video Tutorial 6	To familiarise students with implicit tuning patterns in Ceccarelli's *Bow*	Student private prep.
A	40 mins	Group rehearsal of Ceccarelli	To connect explicit descriptions to implicit tunings	Group reading & discussion, teacher-led
E	20 mins	Group reading of 1st page of Smith score; Question: what are *some different ways* we might tune this opening passage?	To elicit embodied discovery of the need for decision making; to elicit critical engagement with this process	Group reading & discussion, teacher-led
S/A	60 mins	Group reading of whole Smith score; periodic discussion and group decisions about tuning	To introduce Linda C. Smith's score; to present and give practice of various decisions involved in actualising the score; to provide the opportunity for the group to discuss these decisions and begin forming a collective interpretation	Group reading & discussion, teacher-led

Week 7: Listening Outward/Listening Inward

Aims: To present and give practice of directed listening in various tuning environments.

Learning Objectives: To explore directed listening *to others* while playing, and listening *to oneself* while others are playing.

Technical Objectives: To give practice of tuning *to oneself* (or one's own instrument); to give practice of tuning *to others*; to give practice of tuning to an *un-stated* or *unsounding* reference pitch.

Materials: all scores

ESA Lesson Plan (Week 7):

Stage (E/S/A)	Time	Procedure	Aim	Interaction Pattern
E	20 mins	Question: We now have many tools to help us make decisions about intonation, but while playing *how do we know what to tune to?*	To facilitate discussion of inner and outer listening	Group discussion, teacher-led
S/A	30 mins	Group task: rehearse passages from Oliveros & Mc Laughlin	Embodied discovery of tuning to oneself or to one's own instrument	Small student groups playing, teacher-supervised
S/A	30 mins	Group task: passages from Ceccarelli & Brook	Embodied discovery of tuning to others (building of complete harmonies among group)	Small student groups playing, teacher-supervised
S/A	40 mins	Group task: passages from Smith	Embodied discovery of tuning to an unstated/unsounding reference pitch	Small student groups playing, teacher-supervised

Weeks 8-10: Rehearsals

Aims: To rehearse repertoire for end-of-term performance.

Learning Objectives: To give practice of ensemble performance skills, incorporating tuning practice as studied throughout the module.

Technical Objectives: To give practice of *real-time* application of skills learned, and of problem-solving within the ensemble performance context.

Teaching Aids: all scores & materials (review)

ESA Lesson Plan (Weeks 8–10):

The final three sessions of the module took a conventional rehearsal format in order to *activate* knowledge accrued throughout the module to the fullest potential.

7.4 Reflections on this Teaching Practice

The ESA model offers tangible benefits to the particular challenges of teaching in the ensemble rehearsal format. The leader of a student ensemble rehearsal cannot address the moment-to-moment learning needs of each participant, and must rely on active participation and self-directed learning from each player. I found that my Leeds students were overall more likely to invest themselves in an unfamiliar practice if they were enabled to discover that practice through *doing*. Each weekly session was therefore structured so as to elicit questioning from the students that would invite the main area of study for the session. Similarly, the structure of the entire module followed a global ESA arc, with Week 1 serving primarily to engage curiosity about the main subject areas, Weeks 2–6 affording close study of relevant techniques, and Weeks 7–10 activating the practices.

A commentary on this teaching practice is best facilitated by examining the broad areas of technique which were addressed, and how these were propounded in the five pieces presented in the final concert.

Addressing Preconceptions

The word-mapping activity (detailed on pp. 19–22) used in Week 1 proved an effective means of assessing each student's existing knowledge base, while also exposing contradictions between the students' various preconceptions about pitch and intonation. The activity achieved a strong initial *Engage* element for the module because it mirrored what is arguably an ideal ensemble rehearsal dynamic: a conversation between personal but mutually respected outlooks. By asking the students to generate their own keywords, I assessed their awareness of the subject matter within existing pedagogical discourse. Perhaps not surprisingly, the students' language choices reflected those which tend to characterise intonation and microtonality in common practice string pedagogy. Words such as *right, correct* and *exact* typified my *Projected Fret* paradigm; *compromise, adjustment* and *relative* pointed to my *Relational Intonation* paradigm; and *satisfying, comfortable* and *desired* suggested the influence of my *Intuitive Intonation* paradigm.

Correspondingly prescriptive language appeared in the group's keywords on microtonality: *small, smaller than,* and *between the semitones* made clear the prevalence of the chromatic scale as the group's reference point for imagining pitch space. Phrases such as '*not musically notated'* and '*can't be defined'* suggested a further degree of unfamiliarity with practices of representing pitch outside Common Practice Pitch Notation.

A series of initial intonation exercises (Handout 1) facilitated directed listening to intonation, focussing on the sonorities of low-order intervals in various harmonic contexts, the audibility of beating patterns, the learned tendencies of the players, and the physical imperatives of their instruments. These activities clarified several points significant to this research and the effective delivery of the module. First, the students did naturally gravitate toward Just tunings of close-position intervals, and heard these as 'more in tune' than other intonations (such as tunings that more closely resembled 12-EDO). Second, within this tendency, the students were often reticent to tune intervals *as widely* or *as narrowly* as necessary so as to reach Just tunings, and they reflected surprise at *how far* these pitches were from the tempered pitches they were accustomed to playing with piano accompaniment. Finally, the students were largely unfamiliar with the theory and construction of natural harmonic intervals.

Overall, it was clear that the group's concept of intonation technique was somewhat constrained by an apparent contradiction between the instincts of their ears (which gravitated toward relational tunings) and the models of pitch behaviour and construction (primarily based on fixed-

pitch models) to which it appeared they had immediate access in other areas of their musical education. It was also clear that, while the students could readily recognise nuances in the intonation of a given interval, they were not accustomed to listening for any substantial duration of time.

The most frequent question posed by the students during the first session was, 'what am I supposed to be listening *to*?' Active listening to the sonorities of tones and intervals proved challenging for some students, who reflected impatience when asked to listen intently for sustained periods. One student, when asked to play and listen to a sustained interval on her instrument for two minutes, communicated that she expected this activity to be a 'waste of time'. When supported to take a curious attitude to sound and connect the sonority to her embodied experience, the student reacted with shock upon noticing the audible difference tone, exclaiming, 'I didn't know that was there!'

Active Listening

A key component in establishing technique for active listening with the students was enabling them to *physically* sustain tones and trajectories on their instruments for extended periods. Many found gradual movements, both in the left-hand fingers and in the bow, exceptionally challenging, and through the ensuing discussion it became evident that some additional aspects of manual technique would need to be addressed.

The slow glissando material in Pauline Oliveros' *Out of the Dark* provided an effective focus for the class to study gradual movements in both bowing and left-hand fingering. In this work of variable duration, Oliveros indicates only to 'slide very gradually' and to 'take a very long time to reach the half step' within each glissando gesture. Beginning with a semitone glissando of five seconds (which initially seemed 'long' to the students) we worked to extend the glissando gestures to two minutes.

Notably, some members raised concerns that the techniques demanded by Oliveros' score could be seen to constitute 'bad technique' in the context of their classical training. The flexibility of positioning in the hands and arms that can facilitate very slow bowing and pitch-bending seemed to them regressive, in some cases resembling postures they might have relied upon as younger players, potentially working for years to replace with more formal, prescribed postures. This

valuable critical reflection contributed richly to our discussion of received practice and, conversely, allowing the body to play a role in determining what might more appropriately be termed 'constructive' technique, which would continue throughout the module.

The study of *Out of the Dark* highlighted the prescriptive approach to physical positioning taken in some streams of string performance pedagogy. As noted in Chapter 4, the attitude that 'better' *looking* posture leads to 'better' *sounding* playing remains prevalent in some streams of string pedagogy. For this group of students, the greatest leap was to allow their ears to take priority in guiding their movements, and to decide for themselves the sound they found most appropriate to the music they were playing. Where posture and body positioning were concerned, they appeared to need permission to deviate from their received practices, as well as regular reinforcement of the legitimacy of their own listening. From the perspective of this research, this session suggested that string students must to some degree *overcome* received practice in order to access intonation as a wholly embodied technique, and more broadly, to approach the sympathetic performance of experimental music with a focus on pitch and intonation.

Harmonics

Natural harmonics proved a greater challenge for the students than I had anticipated. Surprisingly, many of them were not fully acquainted with the harmonic series and its manifestation along their strings prior to this module. Therefore, the first challenge of this session—and one which persisted throughout the module—was to recognise the sound of the series, and begin to associate that sound with existing technique.

While the group quickly understood the principle and construction of the series, it took some effort for them to recognise its proportions and sound, and to know the location of selected partials. This was compounded by the fact that many players found it unexpectedly difficult to *play* harmonics. Harmonics above the fourth partial were increasingly challenging, and it took some individuals the entire term (ten weeks) to feel confident in this technique. Substantial rehearsal time was dedicated to helping each student determine in what position the harmonics would sound best on their instrument. This topic was also addressed in Video Tutorials 1 and 2.

It emerged through group discussion that the class had encountered natural harmonics only peripherally in their instrumental tuition, and that harmonics had been appreciated for their

timbral qualities (and treated as semi-extended techniques), but not for their implications upon pitch or intonation. This perspective is consistent with the appearance of natural harmonics in classical string literature, which are rarely used above the fourth partial, and are often employed as brief punctuations or embellishments within a passage of stopped pitches (see Chapter 4).

Scott Mc Laughlin's score *Threads of the Social* provided the beneficial constraint of using *exclusively* natural harmonics, and prompted the ensemble to move purposefully within the series, stating directives such as 'glissando to same harmonic in another position' and 'move to the nearest harmonic (up or down)'. Given relatively straightforward tasks such as these, the students began to habituate to the unpredictable dynamics of the technique.

Hearing Proportions

While the technical demands of playing natural harmonics did take time away from other areas of study, this attention was absolutely constructive in light of the larger module plan, as it made way for the discussion of harmonics as components of low-order intervals. Natural harmonics provide a direct and tactile access point to sounding low-order intervals, without requiring the student to have prior knowledge of their sonorities or means of execution. By playing and listening to the interval formed by two adjacent harmonics in the same series, the students began to perceive the sound of low-order intervals, as well as the overall proportions of the series.

In one activity, pairs of students were asked to build intervals by playing two partials from the same series, while the group identified the resulting interval. A common remark, especially from the violinists, was that the *high* register of the harmonics made it difficult to recognise one partial from another. My sense, however, was that the students were accustomed to relying on scales to recognise intervals, and that the non-linear context of the harmonic series may have disoriented them in this exercise.

Taylor Brook's *Ptolemy's Observation* answered this challenge with multiple occasions to match fingered pitches to harmonics sounded by other players. This was particularly helpful in acclimatising the players to Just Major thirds, which they were initially reluctant to place narrowly enough. As seen in the last two measures of Figure 7.1, a B harmonic (the fifth partial of G) provided a convincing pathway to the sounding of a stopped B (-14) one octave lower, which the players could then observe as the 5/4 Just third. This aspect of Brook's score was part of the

initial brief of the commission, and the method was employed extensively throughout the module, both in the context of this score and in isolated tuning exercises, to guide the students toward hearing proportional sonorities.

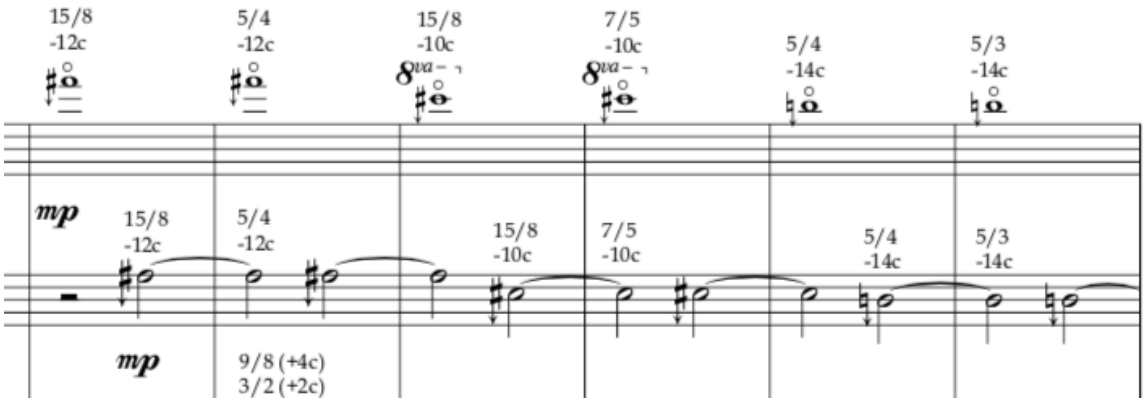


Figure 7.1 *Brook's* Ptolemy's Observation*: matching harmonics*

Difference tones proved an effective means of establishing intervals in the ears of the students (in much the same manner described in *Slip Minuet*, 6.1). Isaiah Ceccarelli's *Bow* afforded multiple iterations of a small set of intervals, which allowed the players to return repeatedly to component pitches, refining their placement and accommodating new sounds in their aural vocabulary. This was particularly helpful with intervals such as the septimal seventh, which was initially not an intuitive sound for the players to access—in one humorous instance, a violinist sounding a 7/4 interval protested, 'is it supposed to sound this *rank*?!' Further experimentation with this interval, and the consonant *dominant* sounding harmony produced by its difference tone, reassured this student and helped the group absorb the new sounds of Just intervals into their aural technique. Substantial attention was given to this topic in Video Tutorials 4, 5 and 6.

Reading Notation, Making Decisions

The challenge of reading microtonal notation was not only one of deciphering—in familiarising with new lexicons, the students had to come to terms with the ultimate indeterminacy of all notation, and begin to make decisions based on their own technique and experience. Linda C. Smith's *Orient Point* gave practice of harmonic contexts in which the intonation of discrete intervals was not always obvious.

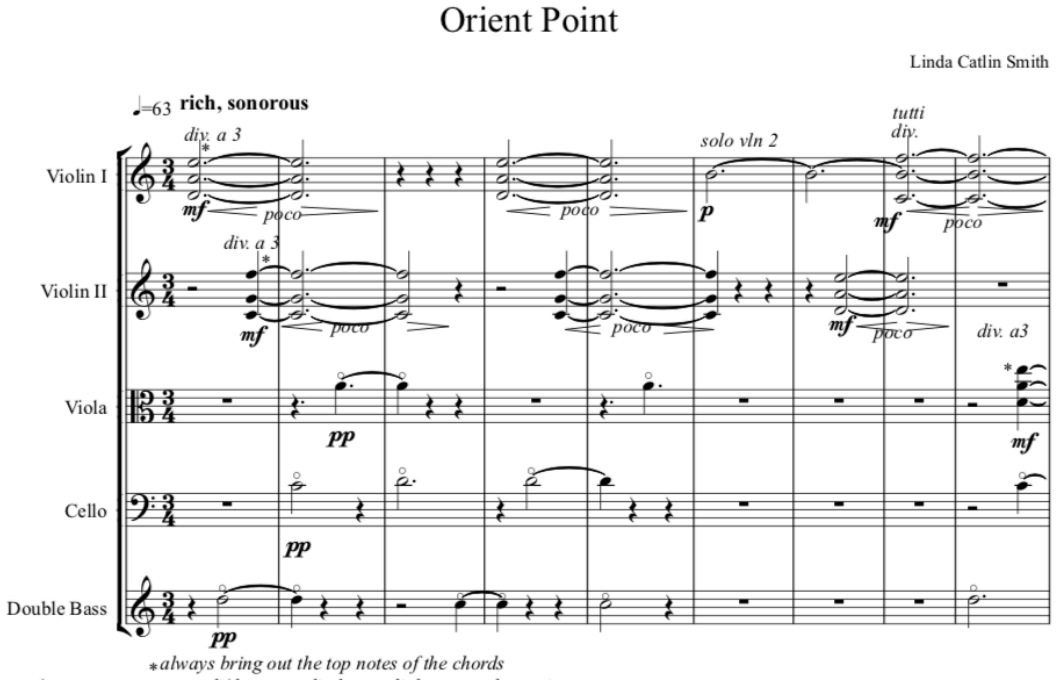


Figure 7.2 *Linda C. Smith's* Orient Point

In the opening measures, for example (Figure 7.2), the players of Violin 2 must decide to which reference pitch this cluster will be tuned. Smith's instructions to 'always bring out the top notes of the chords' suggest that the intonation of the F may guide that of the other pitches, however there remains a decision—whether, among possible other options, to take the harmonic D in the bass as the reference (giving 5/4, F-14), to acknowledge the G within the cluster and maintain consistency with open strings (potentially giving 7/4, F -35), or to preserve a perceived melodic relationship with the preceding E (perhaps giving 15/16, F -10).

It was made explicit to the students that, at least in my mind, there is no 'right' answer to this tuning question—but that their engagement with the question would inevitably broaden their technique; this was the primary aim of the discussion. The group proved capable of effectively applying their knowledge of ratio models toward the discussion and mutual understanding of implicit or ambiguous harmonies, having absorbed a common vernacular with which to express intent and describe their audiation.

‘Something completely new’ (What I carry forward)

Following the completion of the module, one student wrote to me: ‘I just wanted to say thank you for being so resourceful during this semester and really teaching us all something completely new’. Appreciative as I was of this enthusiastic response to the material, it also articulated very explicitly a surprising conclusion that had emerged in the process of teaching—that the techniques propounded, which I considered to stem intrinsically from elements of intonation technique essential string playing, appeared to the students really *new*.

It certainly came as no surprise to me that the class had not encountered microtonal notation prior to this module; equally I had anticipated that many of the sounds of Just intervals (difference tones, beating patters, tuneable dissonances, etc.) might initially be challenging or unfamiliar, and designed exercises which could ease these aspects into their technique. However, it became increasingly apparent across the module that intrinsic connections, which I hoped would surface between the new techniques being developed and the students’ existent techniques of intonation, needed to be repeatedly reinforced.

My message to them across the term was consistently: *this is not new technique, it is a reframing and an expansion of technique you already have.* It took time for some individuals to be able to see microtonal notation, as one student put it, as ‘just more tuning’, and to recognise their own capacity to imagine and sound pitch, irrespective of the mannerisms of its notation. It was my conclusion that those students who absorbed the Learning Objectives of the module most comprehensively, and reached greater facility with the material, did so because they set aside the need for my validation of their intonation, and began deciding for themselves what was *in tune* through developing a technique of critically engaged, reflective listening. It is with this attitude that I propose any practice of intonation can feed back into the epistemic cycle, informing and enriching a young musician’s developing technique.

8. Why I'm once again ready to listen to more than intonation… (What I carry forward)

'…the best microtonal music is, at the end of the day, simply music'
(Gilmore, 2005: 4).

The fundamental incompleteness (Spatz, 2015: 63) of epistemic practice—its potential to 'unfold indefinitely' (Knorr Cetina, 2001: 181) and 'rupture' in the body of the practitioner, creating 'unexpected new objects relevant to knowledge' (Schwab, 2015: 122)—makes the summing up of a project like this necessarily inconclusive.

At the outset, I posed some emergent questions which I suggested might run through this research. I now have a clearer sense of how to answer them, at least as they impact upon my own creative practice. So then, from the top:

> *1. What is the relationship between **intonation** and **microtonality**, and how can these approaches to understanding musical pitch relate to one another in 21st century string performance?*

Intonation and microtonality are mutually beneficial ways of knowing musical pitch. Intonation is known in the body through technique, and instantiated in practice whenever a string player sounds pitch. Intonation is an integrated component of pitch sounded on a string instrument, necessitated by the material affordances of the instrument—there are very few cases where the sounding of a pitch does not involve a player's intonation technique. I have argued that a *relational epistemology* of pitch (one in which pitches are modelled, defined and imagined in relationship to other pitches) is appropriate and in many cases inevitable in a string practice context.

Microtonality is also about modelling pitch relationships, and thus, as Bob Gilmore (2005: 4) has reflected, may seem to be something of a redundant concept in the context of string intonation technique. As one of my Leeds students very astutely commented, 'so, all this microtonal stuff is just more tuning?' Nonetheless, microtonal models furnish socially defined, symbolic descriptions (Spatz, 2015: 31), which I have argued can feed into a reflective dynamic of

embodied technique. A string player's *embodied practices* of microtonality are thus structured by their *technique* of intonation.

> *2. What is a **technique of intonation** and how may this area of **embodied knowledge** be directed in **practice**?*

I view my intonation technique as *embodied knowledge of pitch space* that defines how I practise musical pitch, following the premise set out by Ben Spatz. I have proposed (Chapter 1) that intonation technique might be represented as an epistemic cycle involving three continuant processes: enactive/manual, observational and reflective. In contrast to a what I view as a disproportionate focus on manual technique propounded by many current and historical string players (Chapter 4), I have suggested that *listening* and the *aural imagination* are integral elements of intonation technique. In line with Spatz's assertion (2015: 11) that embodied practice can include 'thought, mind, brain, intellect, rationality, speech, and language', I have furthermore argued that various approaches to *modelling* (Chapter 3) and *notating* (Chapter 5) pitch can serve as integral materials in activating the aural imagination.

The *Instances of Practice* presented in Chapters 6 and 7 give evidence of concrete 'moments of doing' (Spatz, 2015: 40) in which my embodied knowledge was put to use. Through these reflections on practice, the interaction between components of my technique and the *material affordances and agencies of the instrument* are elucidated.

> *3. How can string players interact with systems of **notation**, and make informed choices in our practices of notated scores?*

Notation may be regarded as 'structured meaning potential which is sensitive to context' (Lely & Saunders, 2012: 74). Notation attempts 'to circumscribe and make manifest the processes by which we form cognitive representations of musical materials' (Gilmore, 1995: 458), furnishing socially-defined signifiers that provoke the aural imagination (Gottschalk, 2016). Notation can incite embodied response, as imagined action may be adapted into the physical domain (Natraj & Gangully, 2018: 998). Notation can be overwritten and manipulated through practices of annotation, and thus may 'help to chart the genesis of a piece by giving a glimpse of its developing poesis' (De Laet, Cassiers & Van Den Dries, 2015: 51). Notation furnishes descriptions which are always incomplete, as Knorr Cetina (2001: 184) argues:

> a stable name is not an expression and indicator of stable thinghood. Rather, naming … is a way to punctuate flux, to bracket and ignore differences, to declare them as pointing to an identity-for-a-particular-purpose.

To paraphrase Sally-Jane Norman (2016a), there are things I want to do with notation, and there are things I want *it* to do. In the wake of this research, I find myself telling students: 'Your body isn't here to activate scores; scores are opportunities to activate your body.'

> *4. How can these reflections on techniques and practices of intonation and microtonality be impactful in the performance and pedagogy of new music?*

It would be too simplistic to state that the conclusion of this research is that tuning is really just a way of listening, but there is something to that. I came to this research regarding sound as an end point to practice; technique (knowledge housed in my body) was directed toward sound-making. I wanted to understand the relationships that could be formed by musical pitch—I have ended up reframing that question as being concerned with the relational space that defines my practice.

I carry forward many new pathways of technique into my future practices of playing and teaching. This research has enabled me to perceive low-order intervals by way of their difference tones, and to make score annotations that support this embodied technique (6.1). Within varying 'harmonic identities' (Szlavnics, 2018) the negotiation of *regions of tolerance* can enable material explorations of *tuneability* (Sabat, 2005), alongside which I have considered the thresholds of repeatability (6.2). I have explored the implications of predictive or anticipatory strategies that facilitate larger-scale (multi-measure) intonation patterns, both in determinate (6.3) and indeterminate (6.5) harmonic environments.

If I might draw any personal 'conclusions' from this work, the first would be that intonation technique is not about being *in tune*, it is about *tuning*. Even in the presence of highly specific microtonal notation (6.4) I locate creativity, as well as rigour, as much in the reflective processes of intonation technique as in the outward signifiers of any instance of practice. The second would be to recognise that embodied technique furnishes common epistemological pathways that connect practices of seemingly disparate genre, aesthetic or content. Even in the absence of left-hand fingering (6.6), intonation technique is present in the embodied *recognition* of pitch. Both of these insights suggest to me that intonation technique is ultimately about participating in a relational dynamic through a sustained and rigorous practice of listening.

Some of the strategies discussed here may be helpful to other players. My investigations into modelling and describing pitch space have certainly helped me to sort the constructive from unconstructive elements of my implicit sense of tuning, and to acknowledge how learned responses and received practices might help or hinder my technique. In Chapter 1 I posed the question: *how might our practices of microtonality inform and enrich our techniques of intonation?* I perceive that my practising of microtonality has refined the sensitivity of my observation strategy (Gilmore, 1995: 458) in the sounding of musical pitch. Subjectively, I feel more facility in my technique of intonation—which, ironically, I now feel carries less significance for my artistic practice than it might have at the outset. Tuning has become a carrier for a wider practice of listening.

Perhaps the more profound impact of this research has been on the teaching practice which I am now so fortunate to pursue at Goldsmiths. In working with my students, I am struck by the wide-reaching applicability of these contemplations of embodied practice in many areas, very few of which have much to do with intonation. During a recent discussion on the role of notation in embodied practice, I asked my students, *how can you embody a score?* Their answer was surprising and obvious in equal measure: *how can you not?*

As well as giving a pleasingly concise summation of this research, this answer divulges the profound implications for developing musicians of approaching their technique as embodied knowledge (Spatz, 2015). I observe benefits of this epistemology of practice in areas ranging from instrumental technique to performance anxiety, occupational health to research through creative practice.

'Epistemic Practice', as Knorr Cetina (2001: 185) puts it, is 'based upon a form of relationship … that by the nature of its dynamic transforms itself and the entities formed by the relationship'. This research placed intonation technique at the foreground of my practice, and in doing so reframed that practice as one absorbed by a thick relationality. This focus on the relationships between pitches has brought to light other relationships—between different components of technique, my body and the instrument, my practices and those of others, and between ways of knowing.

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Appendices

Appendix A

USB Drive (.wav Audio Recordings)

Track 1.	Martin Arnold: *Slip Minuet* (2014)	23:42
Track 2.	Chiyoko Szlavnics: *Freehand Poitras* (2008)	11:01
Track 3.	Howard Skempton: *Tendrils* (2006)	19:42
Track 4.	James Weeks: *Windfell* (2017)	59:42
Track 5.	John Cage: *Four* (1989)	30:00
Track 6.	Scott Mc Laughlin: *The endless mobility of listening* (2015)	72:00

Appendix B

Advanced Intonation for Strings: Handouts

1. Leeds Handout 1 – Exercises for Listening to Intonation
2. Leeds Handout 2 – String Harmonic Fingerings
3. Leeds Handout 3 – Familiar Intervals found in the Harmonic Series
4. Leeds Handout 4 – Constructing a Pythagorean Major/minor Scale
5. Leeds Handout 5 – Comparing Pythagorean, Equal Tempered and Just Tuning Systems
6. Kimber graphic comparison

Leeds Handout 1

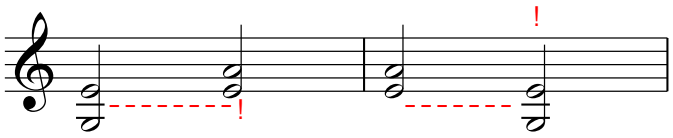
LSTwo Ensemble — Advanced Intonation for Strings
Week 1: Exercises for Listening to Intonation

1. Two E's

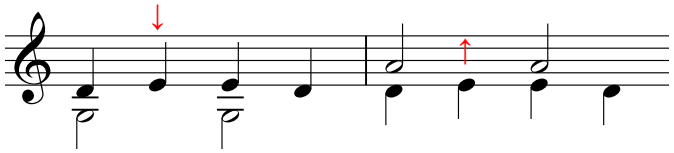
Start with E on your D string…
1) Tune it as a 6th with G below — really listen for that ringing, smooth intonation.
2) Keep your finger where it is… now try out that same E as a 4th with A above. What do you notice? What must you do in order to tune the E with the A?
3) Now try your new E with G again. What do you hear?

➜ Try this exercise individually, then in pairs.

Ex.



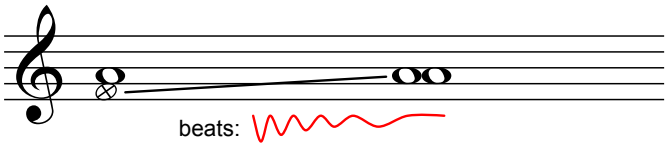
Variation.



2. Hearing Beats: Unisons

Beats are the pulsations we hear when we play a pitch which is *almost* the same as another pitch. Try hearing beats on your own instrument by *sliding very slowly* into a unison with one of your open strings. As you approach the perfect unison, the beats will start to slow down — listen that moment when the beats stop and the tone sounds completely smooth.

Ex.



Here are two links to helpful videos that explain exactly what's going on when we hear beats:

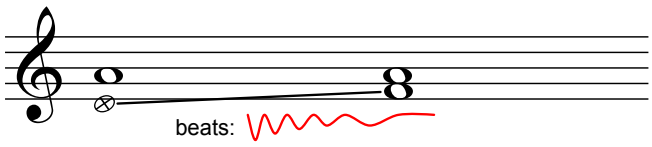
- https://www.youtube.com/watch?v=4M72kQulGKk
- https://www.youtube.com/watch?v=Ca91iOVGd9A

3. More sliding 'into-tune'

Sometimes it's difficult to tell exactly *where* you want to place a pitch. You can use the *sliding-into-tune* exercise to test any interval.

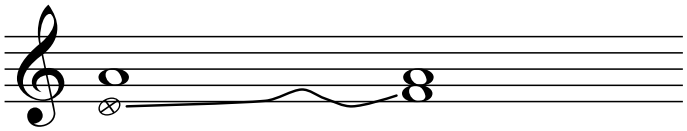
Start with an interval that's obviously 'out of tune' and slide towards your goal — listen for that moment when the beats stop and the sound becomes smooth and resonant.

Ex.



You can also slide *around* the pitch you're trying to tune.

Ex.

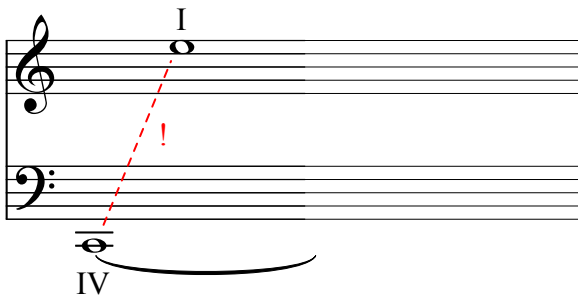


4. Open String Conundrums

An exercise for pairs — violin & viola/cello. Make sure both instruments are tuned to the same A, and in perfect fifths (listen for beats!).

a) Cello/Viola — play your open C, long and sustained.
b) Violin — add your open E… Does the 3rd sound in tune?

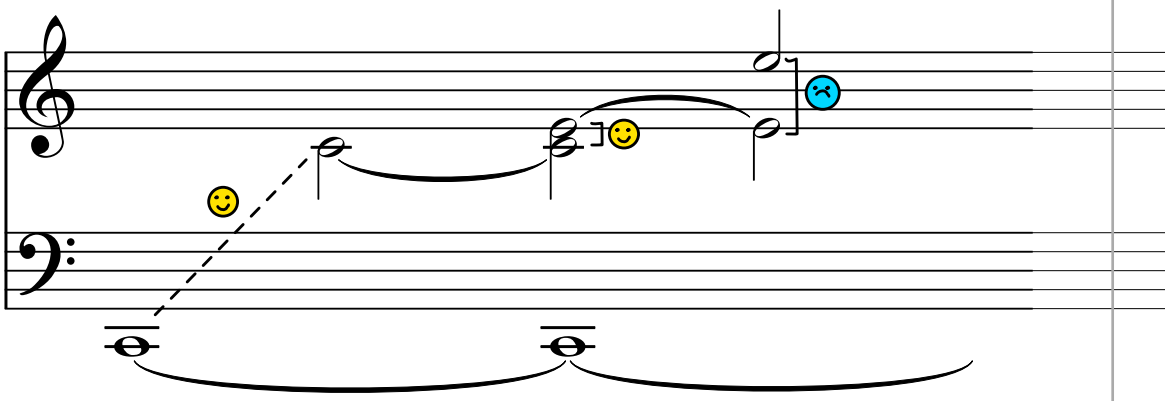
Ex.



Variation for three players:

a) Cello/Viola — play your open C, long and sustained.
b) Violin 1 — play a C on your G string, making sure you tune a perfect octave to the cello. Now add the Major 3rd above (E on the D string).
c) Violin 2 — add your open E string. Does the octave sound in tune?

Ex.



5. Pass the thirds

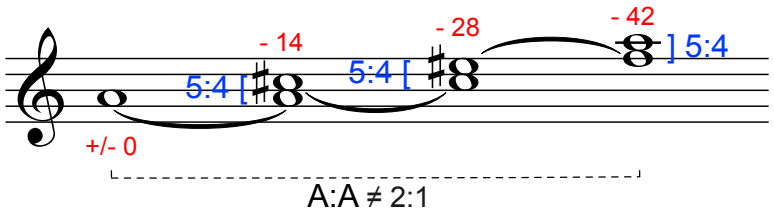
An exercise for groups of 4.

a) Player one starts by playing an open string — long and sustained.
b) Player two adds a note, a Major 3rd *above*.
c) (Player one stops.) Player three adds a new note — a Major 3rd *above*.
d) (Player two stops.) Player four adds a new note — a Major 3rd *above*.
e) Compare player four's note to player one's note. What has happened?

Variation: for the whole group.

a) Player one starts by playing an open string — long and sustained.
b) Player two adds a note, either a Major or Minor 3rd *above OR below.*
c) (Player one stops.) Player three adds a new note — either a Major or Minor 3rd *above OR below*.
d) (Player two stops.) Player four adds a new note — either a Major or Minor 3rd *above OR below*.
e) Continue until everyone has played a note. Now compare your ending note to the Player one's first open string. What has happened?

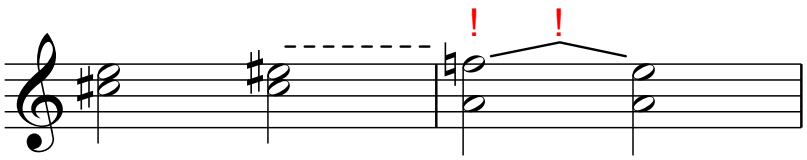
Ex. A chain of pure (Just) Major 3rds:



6. E# = F?

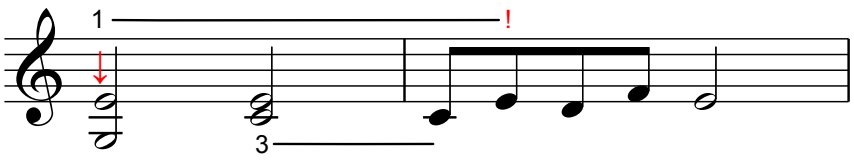
When we look at a piano keyboard, e# is the same as F. This is not always the case on stringed instruments. Try tuning the e#/f note as follows and hear the difference between this note in two contexts:

Ex.



7. Melodies vs. Harmonies

Sometimes in classical string music we tune the same note *differently*, depending on whether it is part of a melody or a harmony. Try this example and think about how you would choose to tune the E's:

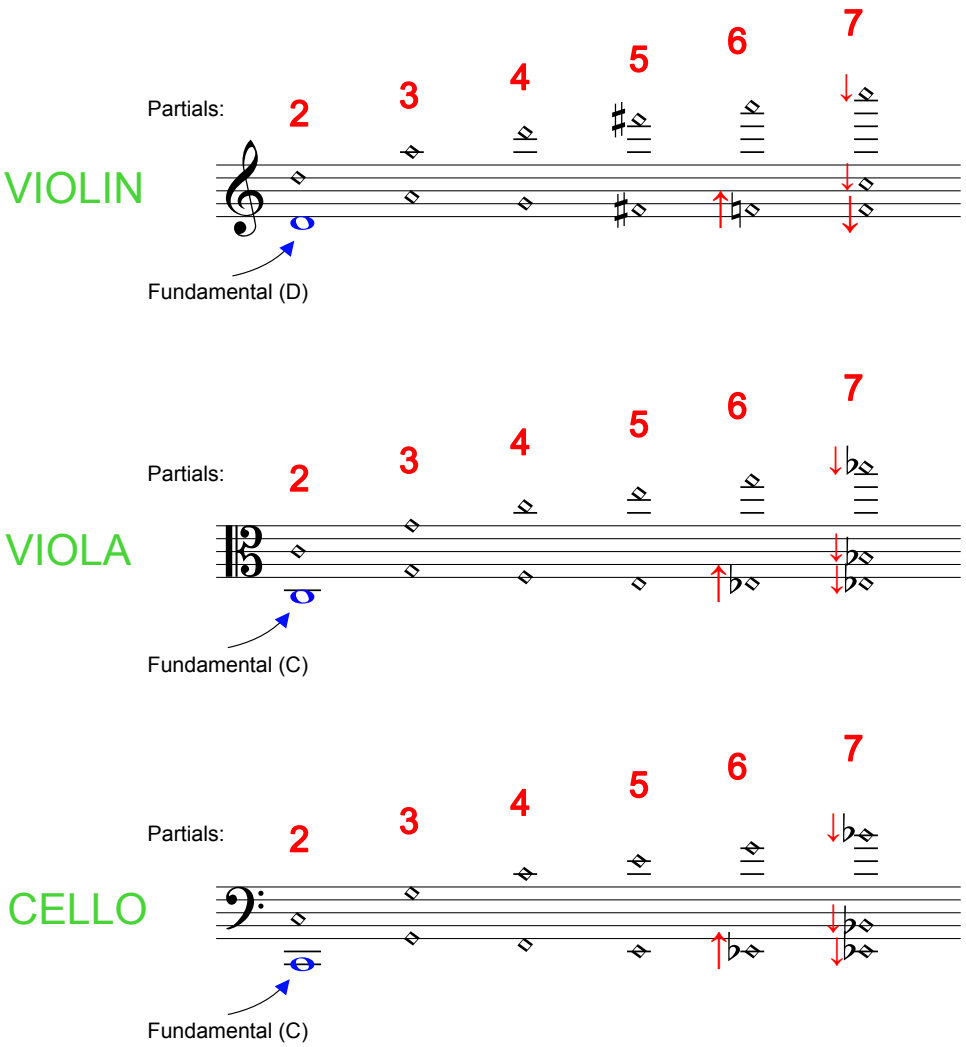


*Exercises adapted from Christine Heman's book *Intonation aux streichinstrumenten (Barenreiter, 1964)*.

Leeds Handout 2

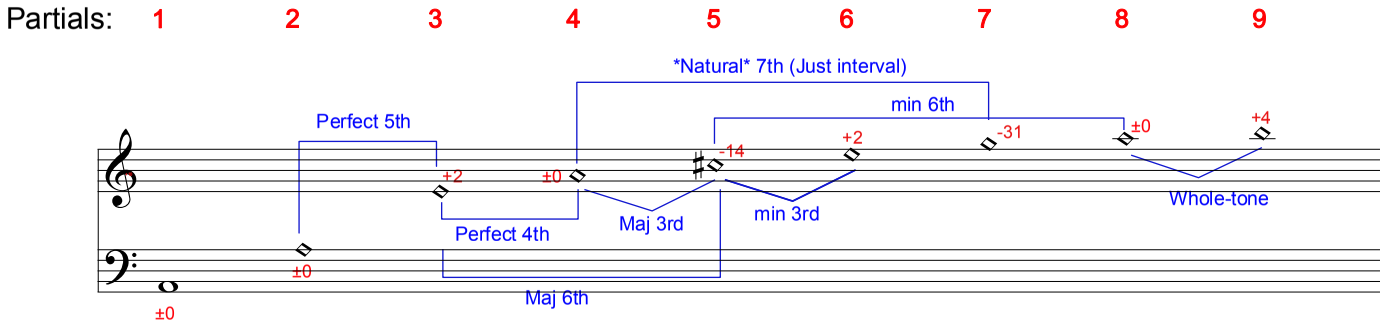
String Harmonic Fingerings

The easiest places to play partials 1-7 (same for all strings)



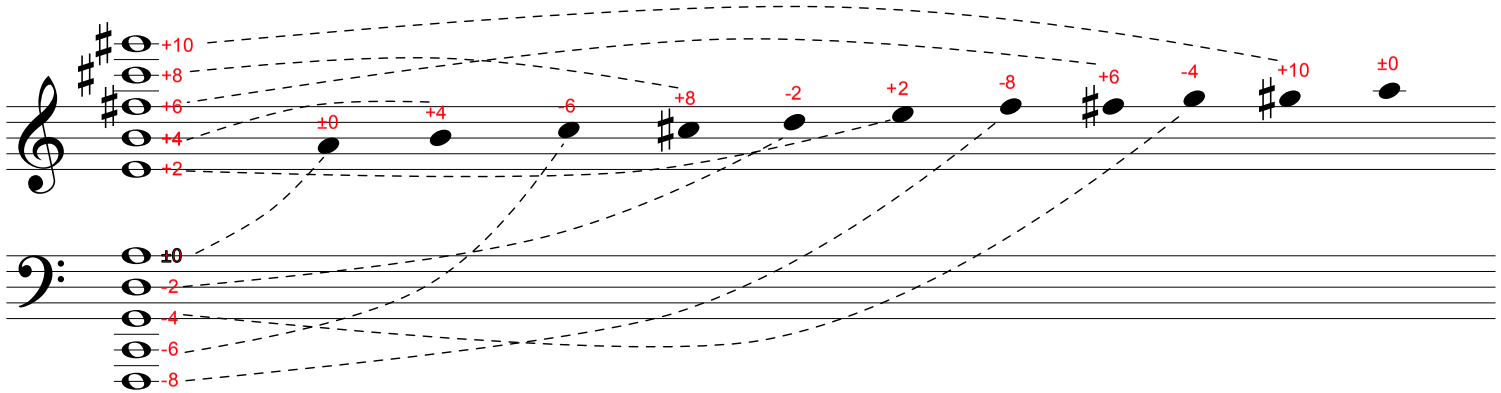
Familiar Intervals Found in the Harmonic Series

- The Harmonic Series contains the **natural** versions of all the intervals found in Major and minor scales
- These natural versions of the common intervals are called **'Just Intervals'**
- **Octaves**, **4ths**,**5ths** & **Whole-tones** are *almost* the same size as their Equal Temperament (ET) versions
- The difference is much greater with **3rds** & **6ths**: Major 3rds & 6ths are narrower; minor 3rds & 6ths are *wider*
- The Just **7th** is *so much narrower* than the ET 7th that it can sound unfamiliar – except when played as part of a chord
- Harmonics can help us hear the intonation of **non-beating**, **pure intervals** that help us sound **'IN TUNE'** on our stringed instruments
- **Just intonation** is most often used to tune harmonies and chords – it's sometimes even called 'Harmonic Intonation'



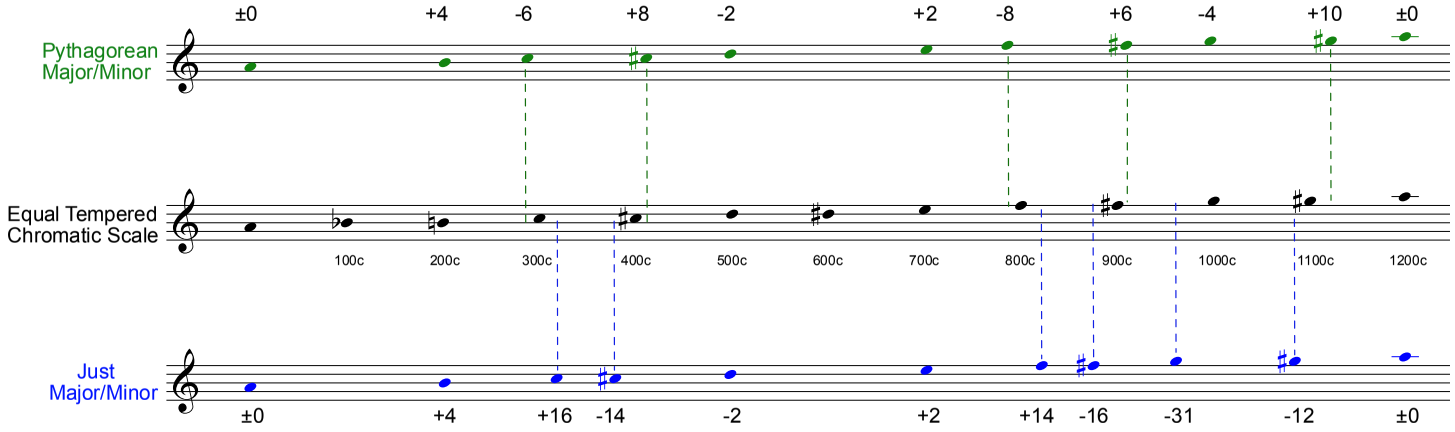
Constructing a Pythagorean Major/minor Scale

- Pythagorean scales are built from stacked 5ths – they are the basis of the Major/minor scales we string players practice daily
- A **Pythagorean 5th** is the same as a **Just 5th:** the simple, non-beating proportion of 3:2 (see Harmonic Series handout)
- These **natural** 5ths are just slightly **wider** than the ET 5th (2c), but this small difference adds up the more 5ths you stack
- In Pythagorean intonation the difference between **Major** and **minor** intervals is more distinct than in ET or Just intonation – Ex: the minor 3rd is a little narrower, and the Major 3rd a little wider than ET (and in Just intonation the opposite is true!)
- This slight exaggeration helps us define **keys**, and therefore Pythagorean intonation is most often used in string playing when we play **melodic** lines – it's sometimes even called 'Melodic Intonation'



Comparing Pythagorean, Equal Tempered and Just Tuning Systems

- **Tuning Systems** are methodical ways of organising and understanding **pitch space**
- **Pythagorean** intonation is based on stacked **5ths**, and can create clear **melodic** contour with distinct **Major/minor** intervals
- **Just** intonation is based on the **Harmonic Series**, and can create consonant, **non-beating harmonies**
- **Equal Temperament** is a **compromise** that allows instruments of **fixed-pitch** to sound equally in (or out!) of tune in all keys
- String instruments have **flexible pitch**, and don't need to rely on the Equal Temperament compromise
- **BUT REMEMBER:** intonation is not about 'right' or 'wrong': it is subtle and complex, and often there are many good answers to a tuning question. With practice and experience, curiosity and engaged listening, we can develop our own **tuning practice** so that we can make **informed decisions** that reflect our **artistic individuality!**



Leeds University LSTwo – Advanced Intonation for Strings
Week 2: Tuning Systems

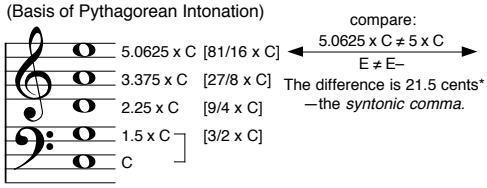
Kimber Graphic Comparison

Melodic and Harmonic Intonation in Relation to Equal Temperament

When playing melodically we are influenced by the compelling relationships among perfect intervals—fourths, fifths, and octaves. When tuning chords and double stops we are influenced by the harmonic series, including harmonically pure thirds and sixths. When playing with keyboard accompaniment we are influenced by equal temperament. To play in tune we must weave an artistic path among these influences, listening intently and adjusting to achieve the most musically satisfying effect at any given moment.

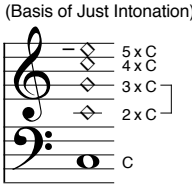
1 · MELODIC INTONATION

Harmonically Pure Perfect Fifths
(Basis of Pythagorean Intonation)



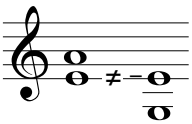
2 · HARMONIC INTONATION

The Harmonic Series
(Basis of Just Intonation)

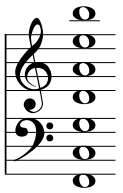


Every note we play is actually a series of harmonics extending even beyond the pitches shown here. When we tune harmonic intervals, as in double stops and chords, it is agreement among harmonics that informs us that the notes are in tune with each other.

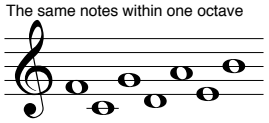
Pythagorean E is higher than the E– of the harmonic series of C. While melodically desirable, E is not in tune harmonically with the C (or G). Adjustment is needed when both E and C (or G) are sounding at the same time. We can observe this by playing the two double stops at right. The E must be adjusted!



Pythagorean Tuning Extended to Yield
the Seven Notes of the C Major Scale

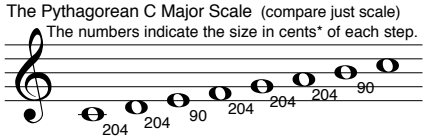


The same notes within one octave



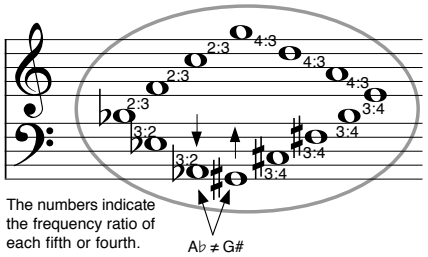
These pitches, in stepwise order, form the Pythagorean C major scale below.

The Pythagorean C Major Scale (compare just scale)
The numbers indicate the size in cents* of each step.



Notice consistently wide whole tones and narrow semitones, reflecting our "expressive" melodic tendencies.

Pythagorean Tuning — Overlapping "Circle" of Fifths

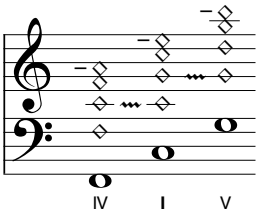


The numbers indicate the frequency ratio of each fifth or fourth.

The ♭/# difference is 23.5 cents* — the *Pythagorean comma.*

The Pythagorean comma reflects our melodic tendencies to play sharps higher than flats and to emphasize major/minor distinctions. (Harmonically we must often do the reverse.)

The Primary Triads (I, IV, V) in C Major
Tuned Harmonically (Just Intonation)

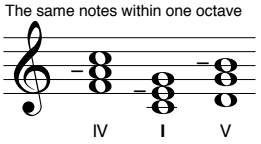


〰 = partials that coincide when tuning pure fifths

The roots of the primary triads are pure perfect fifths apart. The third and fifth of a just triad are tuned in relation to the harmonic partials of its root.

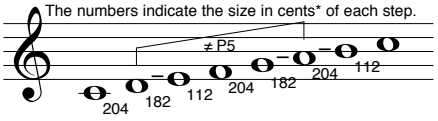
Note that the third of the just triad is a comma lower than if it had been derived by tuning only perfect fifths (Pythagorean).

The same notes within one octave



The pitches of these primary triads provide the notes of the just intonation C major scale below.

The Just Intonation C Major Scale (compare Pythag. scale)
The numbers indicate the size in cents* of each step.



Note that the interval from D to A– is a comma narrower than a true fifth, requiring adjustment when both notes are sounding at the same time. Most players find the 182-cent whole tones and 112-cent semitones melodically less satisfying than their Pythagorean counterparts.

3 · EQUAL TEMPERAMENT

Equal temperament is the present-day [mis]tuning of keyboard instruments. It avoids the Pythagorean comma by using fifths that are about 2 cents (1/12 comma) narrow. Unlike historic keyboard temperaments, it makes no attempt to provide any harmonically pure thirds. Equal temperament, with its 12 equal semitones, only approximates true intervals, although it does so equally in all keys. **Good intonation is better!**

2005 Michael Kimber

* There are 1200 cents in an octave —
100 cents in each semitone on the piano.

Appendix C

USB Drive (.mp4 video files)

1. Leeds_Video Tutorial 1 – Harmonics (pre-class)
2. Leeds_Video Tutorial 2 – Advice on Harmonics (post-class)
3. Leeds_Video Tutorial 3 – Cents Review
4. Leeds_Video Tutorial 4 – Pythagorean 5ths
5. Leeds_Video Tutorial 5 – Just 3rds
6. Leeds_Video Tutorial 6 – JI Tuning in *Bow*

Appendix D

USB Drive (.pdf Scores)

In Chapter 6

1. Martin Arnold: *Slip Minuet*
2. Chiyoko Szlavnics: *Freehand Poitras*
3. Chiyoko Szlavnics: *Freehand Poitras* (Rehearsal Score)
4. James Weeks: *Windfell*
5. Scott Mc Laughlin: *The endless mobility of listening*

* NB. Howard Skempton's *Tendrils* is available from the Oxford University Press; John Cage's *Four* is available from Edition Peters.

In Chapter 7

6. Pauline Oliveros: *Out of the Dark*
7. Scott Mc Laughlin: *Threads of the Social*
8. Isaiah Ceccarelli: *Bow*
9. Linda C. Smith: *Orient Point*
10. Taylor Brook: *Ptolemy's Observation*