String Intonation

Personal Expression and Pedagogical Challenges

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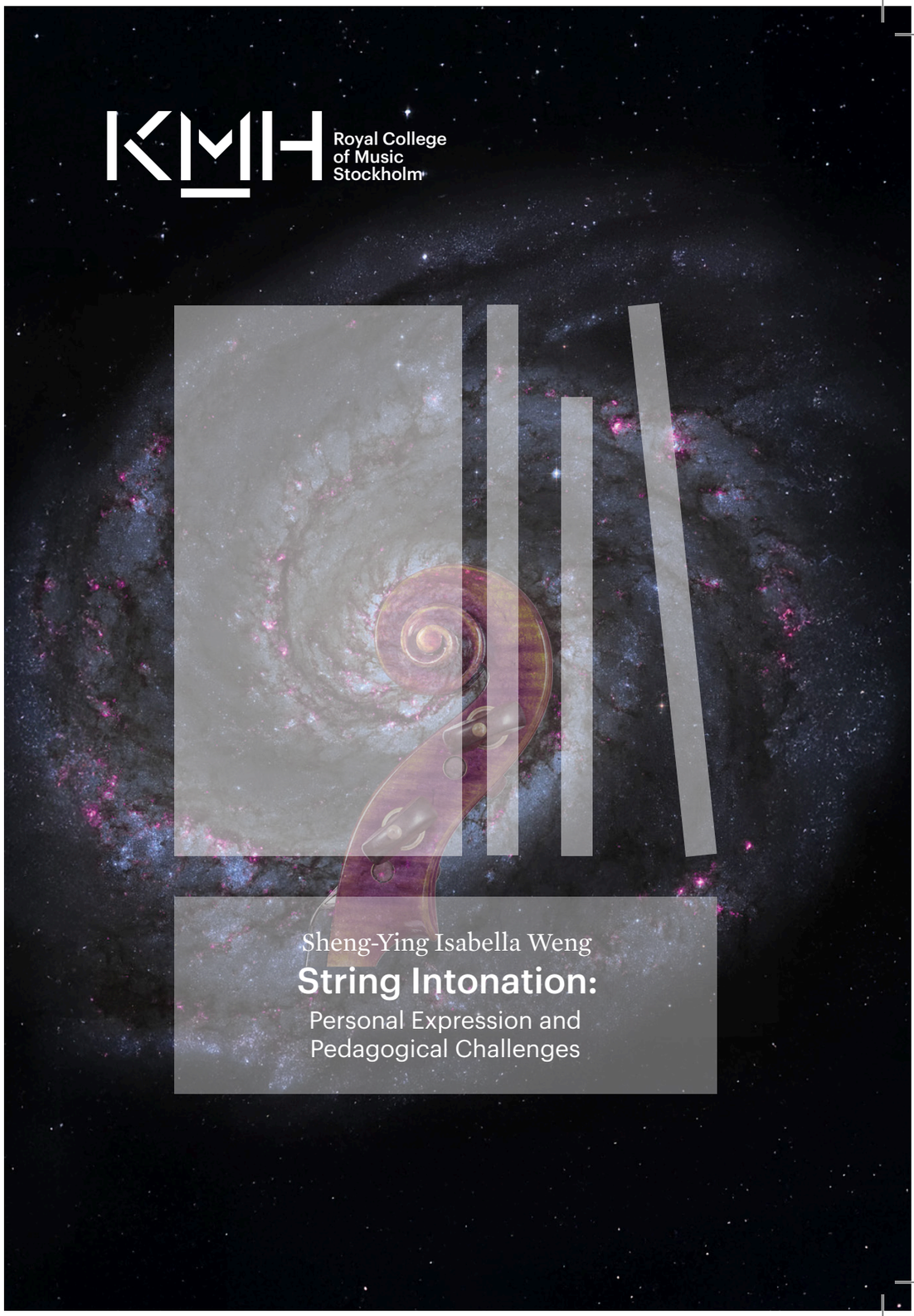

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String Intonation:

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String Intonation: Personal Expression and Pedagogical Challenges

This doctoral dissertation has been carried out and supervised within the graduate programme in Music Education at the Royal College of Music in Stockholm. The dissertation is presented at Lund University in the framework of the cooperation agreement between the Malmö Faculty of Fine and Performing Arts, Lund University, and the Royal College of Music in Stockholm regarding doctoral education in the subject Music Education.

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MADE IN SWEDEN

in memory of my dad and my grandparents

We shall not cease from exploration
And the end of all our exploring
Will be to arrive where we started
And know the place for the first time.

– T. S. Eliot, *Four Quartets*

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Abstract

Melodic intonation of Western classical string performance has generally been considered an expressive tool in music-psychological research. However, empirical studies investigating performance intonation have often related intonation to different tuning systems, leaving music-contextual aspects of performance intonation rather unexplored. Little research has, to date, investigated this relationship between intonation practice and musical context by focusing on musical expression and expressivity practiced by the most accomplished musicians. The question of how the expert knowledge of intonation adjustments is pedagogically transferred to future generations of string players has received even less attention. This work thus aimed to investigate violinists' intonation preferences in listening and in performance, and how intonation practice is currently approached by string teachers and musicians in pedagogical contexts.

This doctoral thesis comprises four original publications, each of which investigates a different aspect of the main aim. The first quantitative study included 19 violin majors and 19 music education majors as two groups that differed in instrumental expertise, investigating their perceptual preferences of melodic intonation of leading tones on the violin. The second study was a mixed-methods study that engaged six highly skilled violinists, all working as professional concertmasters. The study explored the relationship between these violinists' preferences of leading-tone intonation in listening and in their own performances. In the two ensuing qualitative studies, pedagogical aspects of intonation were addressed. First, a survey study with 95 string teachers focused on these pedagogues' views in teaching intonation at elementary and pre-college levels. Finally, the text study investigated how internationally reputed string musicians highlighted in the professional periodical, *The Strad*, approached intonation in their verbal communication concerning expressive performance.

In the first study, it was shown that greater instrumental expertise did not always result in stronger overall preference for the sharpest leading-tone intonation used in the study. Interestingly, such preference was found to increase in the absence of metrical accent (i.e. on off-beat notes), but only among the violin majors. The findings thus suggest an expertise-related connection between intonation preference and meter. In the second study, the

concertmasters' performed leading-tone intonation generally appeared to be sharper than in both equal tempered and just intonations, despite intonational variations within and between the individuals. Moreover, these musicians' performed intonation conformed to the general picture shown in their perceptual preferences. This suggests that highly skilled violinists possess the ability to achieve their intended intonational interpretations of the music. However, much of the temporal influences of expressive intonation seemed to represent skilled musicians' implicit knowledge.

The survey results of the third study showed a rich variety of creative teaching strategies among string teachers. Their focus was mainly on listening, kinesthetics, or tools and practice routines, to make the concept of intonation apprehensible and the skill acquisition more accessible to children and young learners. In the fourth study, textual analysis showed that conveying expert knowledge of expressive intonation was a challenging task for most string pedagogues when only verbal means of communication were possible. There seemed to be a need for more accurate pedagogical vocabulary to efficiently communicate about the expressive potential of intonation.

By shedding light on the practice of expressive intonation in successful string musicians' performance, this work discloses parts of musicians' implicit knowledge, providing some new insights on contextually based intonation practice. In doing so, it provides an example of how science may be used for the benefit of artistic insights in performance. With deepened understanding of both the conventional practice of intonation and what characterises personal expression through intonation, this work has potential implications for teaching intonation. It highlights the importance of cultivating intuition for appropriate intonation early in a string player's instrumental education, as well as the importance of a permissive attitude to various performance and teaching styles in higher music education. Moreover, the findings point to a need for better integrated music theory education to highlight the practical value of theoretical knowledge in artistic performance and in teaching.

Populärvetenskaplig sammanfattning

(Popular science summary in Swedish)

En klassisk stråkmusiker, exempelvis en violinist, börjar oftast sin dagliga övningsrutin med skalor och etyder, för att värma upp sin kropp och väcka muskelminnet så att finmotoriken förbereds för mer avancerat musicerande. En spelteknik som särskilt krävs av en stråkmusiker men inte av till exempel en pianist är intonation. På en fiol eller en cello behöver musikern veta var de ska placera sina fingrar (vanligen i vänsterhanden) på greppbrädan, för att skapa de önskade tonhöjderna och därav melodin. Det är givetvis en av de största utmaningarna för en nybörjare, nämligen att kunna *spela rent*. På ett senare stadium av lärandet, pratas det alltmer om att *intonera*, för till skillnad ifrån att spela piano, ges stråkmusikerna här en unik möjlighet att *färga* sin intonation beroende på musikalisk kontext, genrespecifik konvention, och personlig interpretation med mera.

Som praktiserande klassisk violinist, och nu även stråkpedagog, blev jag nyfiken på om det fanns mer att lära mig om konstnärlig intonationspraxis och intonation i undervisning, med hjälp av ett vetenskapligt perspektiv. En initial forskningsgenomgång avslöjade nämligen en stor kunskapslucka i frågan. Det fanns en uppsjö av intonationsstudier där teoretiker hade utgått ifrån strikta stämningssystem för att förstå musikers intonationspraxis. Ett annat relativt grundligt undersökt ämnesområde var emotioner som förmedlas och upplevs av lyssnare genom musiken. Det som uppenbart saknades var studier som undersökte relationen mellan intonationspraxis och musikalisk kontext, med fokus på musikaliskt uttryck och expressivitet i spelet. Med andra ord behövdes det mer vetenskaplig forskning som också skulle ta vara på praktiserande musikers insikter.

Denna sammanläggningsavhandling inkluderar fyra forskningsstudier. I den första studien använde vi kvantitativa metoder för att undersöka grupptendenser av violinstudenters respektive musiklärarstudenters intonationspreferenser vid lyssning av korta utdrag med soloviolin. Här visade sig att violinstudenter, med deras expertis i det egna instrumentet, föredrog högre intonation på ledtoner som var metriskt obetonade. I praktiken betyder detta att deras intonationspreferenser påverkades av metrisk kontext.

Den andra studien fokuserade istället på yrkesviolinister som arbetade som konsertmästare i professionella orkestrar. Till denna studie insamlades både kvantitativa och kvalitativa data, för att titta närmare på relationen mellan

musikers intonationspreferenser i perception respektive i eget spel. Påverkan av metrisk kontext i intonationspreferenser bekräftades även här. Det som kastade ett nytt ljus på det här forskningsområdet var att konsertmästarnas genomsnittliga resultat visade en god överensstämmelse mellan intonationspraxis och deras preferenser vid lyssning. Vidare fanns det till synes en intressant dynamik mellan musikernas konsensus kring en konventionell intonationspraxis och deras personliga uttryck som avspeglades i individernas medvetna eller mindre medvetna intonationsval.

De två efterföljande studierna tillämpade kvalitativa metoder för att belysa rådande pedagogiska förhållanden och kunskapsöverföring av intonationspraxis. Studie tre var en enkätundersökning som syftade till att förstå stråklärarnas arbete kring intonation på, framför allt, svenska kulturskolor. Resultatet visade en mängd olika kreativa och personliga lösningar i deras arbete, för att i möjligaste mån göra intonation mer gripbar för unga elever, och för att hjälpa eleverna bli bättre på att intonera i relation till musikalisk kontext.

Den sista studien analyserade textmaterial från musikertidskriften *The Strad*. Här undersökte jag hur internationellt erkända stråkmusiker kommunicerade kring intonation, när de delade med sig av egna erfarenheter och insikter om expressivt spel på hög konstnärlig nivå. Som väntat verkade musikers implicita kunskaper av expressiv intonation ha varit svåra att förmedla verbalt. Det tycktes sakna en välfungerande pedagogisk vokabulär för att göra kommunikationen effektivare mellan framstående musiker och målgruppen (det vill säga tidskriftens läsare).

Det här forskningsprojektet är ett exempel på hur vetenskap och konstnärlig praktik skulle kunna överbryggas för att gynna båda disciplinerna. Genom att synliggöra skickliga musikers implicita kunskaper med hjälp av vetenskapliga mätningar och analyser, kan detta avhandlingsarbete förse med potentiellt nya infallsvinklar och förståelser för intonationspraxis, och därav nya verktyg till stråkpedagogers och musikers dagliga arbete. För högre musikutbildningar tycks det finnas två potentiella förbättringsområden: att än mer synliggöra det praktiska värdet av musikteori i konstnärligt uttryck, samt att ytterligare stärka en tillåtande miljö för varierade expressiva speluttryck och undervisningsstilar bland undervisande lärare på musikerutbildningen.

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Sheng-Ying Isabella Weng

Stockholm, March 2025

List of original publications

This doctoral thesis is based on the following original publications, referred to in the text by Roman numerals (I-IV).

I. Weng, S-Y. I., & Huovinen, E. (2024). Expressive semitones: Music students' perceptual preferences for melodic intonation on the violin. *Musicae Scientiae 28*(3), 558–572. https://doi.org/10.1177/10298649231225777

II. Weng, S-Y. I., Huovinen, E., & Ahlbäck, S. (in press). Concertmasters' leading-tone intonation: Do they perform as they assess? *Psychology of Music*. DOI: 10.1177/03057356251319220

III. Huovinen, E., & Weng, S-Y. I. (2024). String teachers on the challenges of intonation: A report from Sweden. *String Research Journal*, OnlineFirst, 1–21. https://doi.org/10.1177/19484992241266528

IV. Weng, S-Y. I. (in press). Intonation and expressivity: Observations on string musicians' views as communicated in The Strad. *String Research Journal*. DOI: 10.1177/194849922513280000

Authors' contributions to the publications

I. The authors designed the study together. The first author collected the data and took the main responsibility for article writing. The second author carried out the quantitative analysis and helped in article writing.

II. The authors designed the study together. The first author collected the data, carried out the qualitative analyses, and took the main responsibility for article writing. The second author carried out the quantitative analysis. The first and third authors were responsible for the audio analysis.

III. The authors designed the study together. The first author analysed the data and wrote the article. The second author collected and prepared the data, helped with the structure of the article and took part in the final stage of the analysis.

IV. The author took full responsibility for all phases of the research process.

1 Introduction

> "Good!... Esprressiivo… high C#... oh yes!" my violin professor exclaims and then hums with the melody. "Hmmm… excellent phrase… Arrrticulate… hmm… and… be determined now… very nice… low Eb… no, no! Ok listen…" Feeling a gentle touch on my bow arm, I lower the violin and try to switch my attention to listening. "You see, we have another voice here. Imagine that a dialogue is going on between two voices, a brighter cheerful one and a darker and serious one…"

This is how it could sound in a typical violin lesson of mine or in a masterclass. As a violin student of the Western classical music, I grew up with constant reminder of the importance of intonation, whether I was rehearsing for a concert, an audition, or a music contest. Later, as a professional musician working in various constellations, following the seemly tradition of intonation practice remained essential. It seems to be a common belief, especially among musicians working with instruments without fixed pitch, that intonation is carefully practised by skilful soloists to make the ultimate difference in expressive performance. At the same time, explaining such practice does not come as naturally to musicians, because of the intuitive practice of intonation that is contextually determined and subject to different musical interpretations and personal tastes. Acquiring the skills needed for expressive performance is a crucial part of higher instrumental music education, and central to music students' own interests in learning (Lindström et al., 2003). There thus appears to be a demand for answers to questions such as: Why is one specific intonation considered "better" than another in certain music? What underlies musicians' common understanding of a fine intonation? How can we explain the relationships between intonation and expressive performance for string instruments? This is what sparked my curiosity for this topic. This compilation thesis is thus an attempt to explore this area further, looking for more clarity and for answers to these questions.

In search of an objective understanding of expressive performance, I initially came across a number of empirical studies concerning emotions communicated in music. To give an indication of the extent of the field, Eerola and Vuoskoski

(2013) reviewed 251 studies published in refereed journals or conference proceedings during a short span of 20 years (1988–2009). To mention just a few interesting examples from the research field, Juslin (1997) recommended a functionalist perspective on emotional communication in music performance by using the Brunswik's (1956) lens model that is an extensively used framework for studying human judgment processes; Van Zijl and colleagues (2014) found that performers' felt emotions affected the auditory characteristics of their performances; Sloboda and Lehmann's study (2001) showed systematic relationships between pianists' (professional or advanced students) interpretative choices in their performances of Chopin's Prelude op. 28, no. 4 and listeners' (trained musicians) emotionality ratings.

In the music and emotions literature, the focus has usually been either on the recognition of the emotional characteristics by the listener or on the felt emotions of the listener (e.g., Gabrielsson, 2001). For a performer, however, musical expressivity in performance might not necessarily involve awareness of specific emotions in either of these ways. While concentrating on the craft of conveying the intended expression through music, the performer's musical expertise might well be manifested intuitively in terms of "apprehension and use of the structure-emotion link" (Sloboda, 2005, p. 256). This means that those musical features that would evoke or be associated with emotions are acquired through years of training and exposure to activities of the musical culture. The induced emotions of a listener thus require less attention by the performer as such. After all, such emotions are distinguished with reference to the listening individual's prior experience and can be influenced by personality traits as well (Vuoskoski & Eerola, 2011a; Vuoskoski & Eerola, 2011b; Vuoskoski et al., 2022).

For the purpose of this compilation thesis, it is therefore essential to differentiate between expressiveness and emotion, not least to narrow down the scope of this work to a manageable topic. Here, I will mainly focus on musical expressions that are realized through intonation by the performer and likewise perceived as expressive gestures by the listener. In this sense, this work is merely interested in the technical, artistic, and pedagogical aspects relevant to intonation in string performance, without direct concern for the particular emotions conveyed to or perceived by the listener.

For discussions on this topic, it is however pertinent to mention those emotion studies that suggest tempo, sound level, timbre, and pitch to be primary conditions for delivering *acoustic cues* (or just *cues*), to create musical expression (Juslin & Lindström, 2016; Juslin & Timmers, 2010). As is commonly known, intonation concerns fine adjustments of the pitch of a tone

(see Chapter 3 for theoretical background on intonation). As Gabrielsson and Juslin (2003) have noted, given that "most discussions of emotional expression in music concern variables in the musical structure specified by the musical notation (e.g., pitch, mode, melody, harmony), the influence of variables in the performance (e.g., articulation, timing, intonation) has so far received less attention" (p. 506). Regarding the influence of intonation for listeners in expressive performance, *cent* (a unit of interval measure equalling the 1,200th part of an octave) is commonly used for accurately describing intonation deviations. Earlier findings confirm that music and non-music majors' responses to intonation can be predominant over responses to other elements of music (Geringer & Madsen, 1981; 1998). Hence, understanding what solo performers do to communicating through intonation seems relevant and important, not least for music educational purposes.

Investigation of intonation in real classical string performances has not been extensive, however, and studies involving the most skilled string players are even rarer. In an early pioneering study, Greene (1936) analysed unaccompanied performances by six professional violinists. Apart from finding a tendency for the players to approximate the interval sizes of the Pythagorean scale, these performers showed slightly different patterns of intonation as individuals. Small's early studies of artistic violin performance (1936) similarly showed application of what he called "tendency tones" to be highly variable in pitch. More recent analyses of violin performers have likewise confirmed such tendencies (Fyk, 1995; Geringer, 2018).

Collectively, these findings indeed strengthen Carl Seashore's (1938) proposal that "artistic expression of feeling in music consists in esthetic deviation from the regular" (p. 9). Terms such as "artistic deviations," "expressive deviations," "systematic variations," or others have occurred frequently in the literature (Gabrielsson, 1999, p. 531). The view of intonation being an expressive device in string performance has thereby become increasingly accepted among music psychologists (see, e.g., Fyk, 1995; Morrison & Fyk, 2002; Sundberg, 2013, Yarbrough & Ballard, 1990).

However, there has not been clear consensus regarding application and pedagogy of expressive intonation in classical string performance. Thus, the primary aim of this work is to generate knowledge on string musicians' intonation practice of the Western classical music, concentrating mainly on the two following aspects:

1. violinists' aesthetic preferences for melodic intonation as listeners and as performers, and

2. string musicians' pedagogical views surrounding intonation practice in various contexts.

This compilation thesis is interdisciplinary in the way that it positions itself at the intersection of mainly two research fields, psychology of music and music education (more specifically, string pedagogy). It investigates musicians' own intonation preferences and practice, and how such expert knowledge is currently conveyed to students. Musical stimuli used in the two music-psychological studies were stylistically familiar to the violinists participating in the studies, in order to achieve ecological validity, as far as it can be achieved in a laboratory environment. Findings of this work will contribute to the literature regarding intonation perception and performance, as well as shed light on expressivity from the perspectives of empirical research, performance practice, and teaching.

The ensuing chapters (Chapters 2 and 3) will introduce the theoretical background of this work. Chapters 4–6 will provide the aims, methods, and results of the four original studies. Chapter 7 will present an overall discussion, conclusions, and implications from this work.

2 Expressive performance

2.1 Expressive devices in performance

Music performance is fascinating in part because it entails so many layers of action. In Fabian's (2015) view, it is a complex and dynamic system that is not only culturally constructed yet individual, but also involves "a multitude elements from the technical to the aesthetic, and from the physical and measurable to the embodied, implied and subjectively perceived" (p. 58). As regards expressivity, Clarke and colleagues (2010) point out that Seashore's (1938) definition of expression as deviations from fixed categories of musical events "has an intuitive appeal because it seems to draw a neat line between those attributes that the composer has explicitly indicated in the score, and those that the performer contributes—the identifiable aspects of a performance that are not explicitly marked in the score" (p. 36).

Undoubtedly, a performer's understanding of the musical material and interpretation of the inherent expression in music is crucial. For the most accomplished classical musicians, their identities as a performer can even be recognizable by the listeners, through the characteristic application of numerous expressive devices. Clarke (2002) outlines timing, dynamic, articulation, vibrato, and timbre of notes and note groups to be "expressive parameters" that are continuously modified by the performer (p. 11). The pioneering music psychologist Seashore (1938) enumerates pure tone, true pitch, even dynamic, metronomic time, rigid rhythms to be some of "the countless devices for deviating from the regular or rigid, including also adherence to the regular as a means of expressing emotion in music" (p. 9). Furthermore, he believes such deviations (or adherences) can be measured.

Hence, while much about the experience of performing and listening to music is hard to capture just by physical description, it is not too surprising that interest in performance measurements has grown rapidly during the 20th century to better understand classical performance practice. Expressive timing, for instance, is often considered a principal parameter in piano performance.

Previous findings show that the listener's interpretation of the emotional expressivity of performances can correspond with the amount of increase or decrease of variations in timing (Bhatara et al., 2011). There is also some evidence for certain standard patterns in pianists' imitations of expressive timing, pointing to the importance for such expressive gestures to be music-structurally anchored for convincing expressive performances (Clarke & Baker-Short, 1987; Repp, 2000).

Another example of performance measurement is to study instrumental or vocal vibrato by measuring intonation (or pitch). Typical points of interest have been to define the pitch centre of the tone (e.g., Brown, 1991) or to understand the role of vibrato in pitch perception (Besouw et al., 2008; Geringer et al., 2010; Geringer et al., 2014; Geringer et al., 2015). Some informal measurements interestingly revealed that violinists use smaller vibrato, approximately half or less of the extent than that of singers' (Prame, 1997).

Above are just a couple of examples from the abundance of empirical studies on expressive performance. More can be found, for instance, in Gabrielsson's two encyclopaedic reviews (1999; 2003). Technical advancements have also led to possibilities for establishing computational models of music performance. In a series of studies, an experienced musician's intuition was used to establish a rule system producing deviations from durations/note onsets, sound levels/dynamics, and pitches, to create automatic performance of music (e.g., Friberg & Bisesi, 2014; Sundberg et al., 1991; Thompson et al., 1989).

Expressive devices as a research topic have been of interest even to musicologists. For example, to address whether the recording industry has fostered a de-personalisation of musical expression compared to the "golden age" (that is, pre-1930s), Fabian (2015) studied forty recordings of Bach's *Six Sonatas and Partitas for Solo Violin*. Among other interesting aspects, this extensive work provides a historical perspective of the "current practice" of Bach in terms of performance style. Tempo, vibrato, ornamentation, rhythm, bowing, phrasing and dynamics were systematically analysed as "performance features." It appeared rather clear that the analogies between mainstream performance (MSP) style and historically informed performance (HIP) style are not watertight, and the "current practice" should and needs to be constantly re-evaluated because practice never stands still.

2.2 Expressive performance in teaching

Previous findings have shown that instrumental music teachers consider expressivity to be the most appreciated characteristic in performers (Laukka, 2004). There is also evidence of high level of agreement between teachers and students concerning the importance of communicating emotions in music performance (Prince & Hallam, 1996). Yet, the expressive aspects in performance are not necessarily always addressed by teachers (for a review, see Hallam, 2010), and the question of how practices of expressive performance are conveyed to students seems to have received little attention. One common strategy in teaching expressivity that students reported as being most effective was the use of metaphor (Barten, 1998; Rosenberg & Trusheim, 1989). However, the effectiveness of such a strategy would depend on students' personal experiences with words and images (Persson, 1996). Juslin and Persson (2002) concluded that teaching expressivity is, overall, a neglected area in music education. Similarly, Hallam (2010) argued that "the cumulative evidence from research over time provides considerable support for the notion that teaching expressivity is frequently not explicit in music lessons and that teaching tends to focus on technique" (p. 799).

Indeed, it is rather common that performers have difficulties in describing the expressive devices that they employ. Some scholars explain that precise descriptions of how to perform a piece of music might be deliberately avoided by some teachers, to encourage the student to develop imagination and personal expressions (Thompson et al., 1989). Whether the avoidance of explicitly addressing expressive performance solely depends on this pedagogical thought is, however, unclear.

Furthermore, instrumental music teachers in higher music education may differ largely in their pedagogy and teaching styles, as well as how they approach expressive performance. As examples, we might take two among the most influential violin teachers of the 20th century in America, Ivan Galamian (1903-1981) and Dorothy DeLay (1917-2002). Both taught at the Juilliard School and were known for their emphasis of tone production. According to interviews with several of their students, Galamian stressed the technique for the bow arm and DeLay the importance of vibrato (Sand, 2000). What differed the most between them was, according to Fabian (2015), their pedagogy. Galamian's teaching style was considered "old school authoritarian," "focusing on technical work and leaving nothing to chance […] because he believed that the violinist's musical personality could be developed later, once [the] technical

command had been achieved" (p. 91). DeLay, on the other hand, "was motherly and had a holistic approach to developing not just technique but the musician and the personality as well" (p. 92). Her goal was to help students to find their own performance styles, becoming independent musicians. No doubt, both Galamian's and DeLay's contributions to classical violin pedagogy were significant, by transferring their personal experiences and expert knowledge of the tradition of classical performance practice to succeeding generations of musicians.

3 Intonation

To obtain a conceptual understanding of intonation, Sections 3.1 and 3.2 provide a theoretical and a historical view of intonation in Western art music. Section 3.3 subsequently address the contextual considerations of intonation practice that are the more specific focus of the current thesis.

3.1 Intonation and tuning systems

Intonation is a term used by musicians to refer to pitch inflections performed on variable pitch instruments such as string and wind instruments. Pitch denotes "highness or lowness in the musical scale and is conditioned primarily on the frequency of sound waves" (Seashore, 1938, p. 53). In search of a better understanding of intonation practice in performance, three tuning systems have been frequently used in music psychology as reference systems: the Equal tempered, the Just (or Pure), and the Pythagorean intonation.

Equal temperament is the division of an octave into a number of equal intervals. The term most typically refers to the standard equal temperament of modern piano tuning that is defined by 12 equal logarithmic steps (semitones) of 100 cents. A set of adjacent semitones within an octave is referred to as the chromatic scale, but most compositions in Western music are based on the diatonic scale that consists of seven tones separated by an invariant sequence of 2, 2, 1, 2, 2, 2, 1 semitone intervals. Important to mention is however that the equal-tempered system is a pragmatic compromise in tuning, due to mathematical complications with untempered tuning systems.

The *Pythagorean scale* is generated from a single and maximally consonant interval, perfect fifth. A complete Pythagorean scale can be generated from a series of twelve perfect fifths corresponding to the frequency relationship of 3:2, which translates to 702 cents (i.e. pure and untempered). What makes it

all complicated and more interesting is that, unlike a series of tempered 700-cent perfect fifths on the piano, this one does not return to an octave multiple of its starting point. There is a small interval difference of about 23.5 cents (roughly a quarter of a semitone), commonly known as the *Pythagorean comma* (see Figure 1).

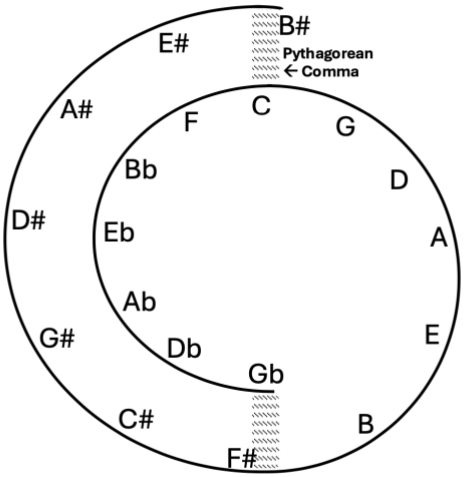

Figure 1 The Pythagorean comma
The Pythagorean comma results from the "circle of fifths" but with the intervals tuned in the ratio 3:2. The figure shows the discrepancy in ratio as the octaves increase.

The Pythagorean scale is, however, not far different from the equal-tempered scale. Apart from the augmented fourth (the tritone), e.g. the interval C–F# (611.7 cents) in a C-major scale that is about twelve cents off, most of the pitches are within eight cents. For a string player it is interesting to note that the pitch F# is 23.5 cents sharper than Gb (which is 588.3 cents from the tonic C) in a Pythagorean scale. This is, indeed, in accordance with the convention of string intonation by which sharps are often played sharper than the corresponding enharmonic flat. Even if the practice in early music may differ slightly in this regard, musicians of period performance approach the Pythagorean comma as an elastic interval too, using inflected intonation as a rhetorical device (Gries, 2012). The phenomenon that appropriate melodic information can be perceived by listeners despite such latitude in tuning of intervals can be called "note abstraction" (Francès, 1988).

Just intonation refers to a system of tuning in which pitches are defined according to whole-number ratios between frequencies. It is based on harmonic series—also known as the overtone series—that optimize consonance between scale tones. This means that the scale notes are tuned in such a way that their fundamental frequencies relate to that of the tonic by small integer ratios: octave (2:1), fifth (3:2), fourth (4:3), major third (5:4), minor third (6:5), major sixth (5:3), and minor sixth (8:5). Unlike the Pythagorean tuning that could be generated by using only perfect fifths (3:2), this simple so-called 5-limit just-intonation system can be generated by using fifths (3:2) *and* major thirds (5:4), where the latter ration involves the number 5. One limitation of just intonation scales is that if the sixth scale degree is tuned according to the ratio of 8:5, then the interval between second and sixth scale degrees will not be consistent with the desired ratio of 3:2 (Thompson, 2013). Previous studies on violin performance have repeatedly shown that musicians' intonation deviated more from just intonation than from Pythagorean or Equal-tempered intonations (e.g., Loosen, 1993, 1995; Mason, 1960).

However, the question of whether theoretical tuning systems can be effectively applied as the main reference point for artistic practice of intonation has been a topic for discussion among music psychologists. A brief historical view of the varying focus in intonation research is summarized in Section 3.3.

3.2 Intonation in Western art music

The online encyclopaedia *Grove Music Online* defines intonation as

> [t]he treatment of musical pitch in performance. It is usually thought of as the acoustical and artistic accuracy of pitch in singing or playing, but it has an indispensable role in musical expression through the deliberate inflection of pitch to shade and colour melody, to create excitement or tension, or as a means of characterizing a particular repertory or style of performance (Leedy & Haynes, 2001).

This definition highlights the interplay between intonation and musical expression appropriate to the intended performance style. A historical view of intonation and its practice in Western music then follows in this article for a theoretical and conceptual understanding. To put it briefly, the vertical intervals of the earliest polyphonic music were constructed from the pure fifths

of the Pythagorean intonation (with the frequency ratio of 3:2) as well as octaves (2:1). The admission of pure major 3rd (5:4) by the 13th century opened possibilities for the triadic sonorities of Just intonation. The drastic shift to 12-tone equal temperament that started in the early 18th century was largely due to the steadily increased dominance of keyboard instruments. From the 20th century and onwards, intonation became

> dominated by the conservatory standard of Pythagorean-shaded 12-equal, but after about 1950 [it] became increasingly inclusive and reformist, under the influence of non-Western music and, especially, of the early-music movement, which brought about a return to just […] intonation, along with a growing understanding that no one intonational basis fits all Western music (Leedy & Haynes, 2001).

As it seems, some kind of a shift in attitude towards the aesthetics in performance intonation took place around the 1940s. What historical events that may have influenced the course are beyond the scope of this work. Nevertheless, the extract above is enlightening for the understanding of why music-psychological research on violin intonation has largely focused on the "conservatory standard" and those conventions that accompany it. Given the reformist attitude and pluralism in performance, understanding the present state of intonation practice is both interesting and necessary, as contradictory as the various facets of this ever-changing "present" may be. Two of the studies included in this compilation thesis (Study I and Study II) will simply follow the footsteps of previous music-psychological research on intonation, with whatever prevailing influences and trends of the performance tradition of Western art music it entails.

As mentioned in Section 2.1, Fabian's (2015) investigation on performances of Bach's violin solos includes analysis of tempo, vibrato, ornamentation, rhythm, bowing, phrasing and dynamics. Although intonation is not among these "performance features", the period during which the violin soloists featured in her work (born from around 1920 to the mid-1980s) have been engaged to music is of interest, because it covers performance practice spanning from the "golden age" (pre-1930s) till present. Two performance styles are clearly distinguished and discussed by Fabian: the historically informed performance style and the mainstream performance style. Interestingly, she also mentions that "most experimental music psychologists have been [investigating the latter]" (p. 26). To delimit this compilation thesis, our discussion will simply follow the music-psychological research tradition,

by exclusively dealing with the mainstream performance style and conventions of intonation practice that accompany it.

It is however necessary to remind the reader of the fact that the distinctions of style and the stereotypical "historical-versus-mainstream" divide have become hard to define (again, see Section 2.1). According to Milsom (2003), this was indeed the case at the early twenty-first century. Even though performers and critics do speak of stylistic differences between violinists, Milsom believes the blurriness between styles to be a matter of individual influences on performers by their teachers and mentors. This view of the teacher's influence might well be true, given previous observations that a soloist rarely diverts from those distinctive interpretations that were developed early in career (Fabian, 2015; Leech-Wilkinson, 2009).

3.3 Intonation as an expressive device

It was clear in Chapter 2 that intonation (or pitch) is one of many coherent expressive devices available to musicians in achieving expressive communication in performance. Vibrato was mentioned in this context to be intertwined with intonation. In addition, the tone quality in violin performance also interacts closely with intonation in listeners' perception (Geringer, Madsen, & Dunnigan, 2001; Madsen & Geringer, 1981). For example, listeners tend to associate sharper intonation with "brighter" tone qualities and flatter intonation with "darker" tone qualities (Geringer & Worthy, 1999; Wapnick & Freeman, 1980; Worthy, 2000). This is, indeed, a parlance commonly used by professionals and in teaching of expressive performance (see the introductory quotation for instance). In other words, intonation deviations can, in some cases, be used as a tool for achieving certain tone qualities to be conveyed as the performer's personal interpretation of the music.

However, contemporary studies on intonation as an expressive device in its own right have been scarce. Gabrielsson (1999) notes that the history of performance measurements has "two distinct periods, one beginning in the early music psychology and running up to about 1940, and the other a restart beginning in the 1960s" (p. 525). The history of research on string intonation seems to have been no exception to this.

Arnold M. Small (1936), who was a professional violinist himself, collected data from some of the leading violinists of his time (including Elman, Kreisler, and Menuhin), to study pitch, intensity, and temporal aspects of artistic violin performance. On the precision of intonation, he concluded that the violinists often deviated from the tempered scale notes, predominantly in the sharp direction, and that what he called "tendency tones", for instance the leading tones (referring to the raised seventh scale degree in Small's study), were highly variable in pitch. Several other tendencies shown in Small's investigation were the generally compressed smaller intervals and stretched wider intervals relative to equal temperament (thus conforming to Pythagorean intonation). These early findings have been repeatedly confirmed in contemporary studies (e.g., Kopiez, 2003; Loosen, 1994, 1995).

Paul C. Greene's (1936) study was conducted with several professional violinists, either working as violin professors or as concertmasters in American symphony orchestras. His investigation similarly showed a violin intonation that deviated from both equal temperament and just intonation. In addition, the results clearly demonstrated individual application of intonation by these violinists—a finding that has been repeatedly confirmed in contemporary studies as well (e.g., Fyk, 1995; Geringer 2018). Both Small's and Greene's studies were published in the last of four volumes edited by Carl E. Seashore (1936) that comprise performance on the piano, the violin, and singing.

Investigations from the 1960s and onwards commonly involved measurements of perceived intonation in laboratory environments, often with an interest in JNDs (just-noticeable differences, e.g., Houtsma, 1968), or categorical perception (e.g., Burns & Ward, 1978). From around 1980, music psychologists became increasingly aware of the musical context and its role in listeners' intonation tolerance (e.g., Fyk, 1982; Marmel et al., 2008; Rakowski, 1990; Rakowski, 1991; Sundberg, 1979; Sundberg, 1982).

As it seems, empirical studies on expressive intonation that exclusively involved practice of the most experienced violinists appeared again first in the 1990s (e.g., Brown, 1996; Fyk, 1995; Rakowski, 1990). Even if much of the research on performed intonation has still conveniently been in relation to different tuning systems, researchers of recent investigations concluded that string players never play exactly in one particular tuning or another (Geringer, 2018; Loosen, 1993). An understanding that no *one* intonational basis fits intonation practice of the Western classical music has seemingly grown stronger. Morrison and Fyk (2002) stated that "Good intonation is characteristic of a musically *sensitive* performance; it supports the beauty and

expressive qualities of the sound" (p. 184; emphasis in the original). In violin performance practice, it is possible to say that there is an "intuitive violin temperament" dependent on musical context and situation (Modney, 2018), instead of the intonation being strictly regulated by theoretical tuning systems. Given this brief review and recently gained insights, the ecological value of the pioneering work by Greene (1936) and Small (1936) emerges even clearer.

3.4 Melodic intonation vs. Harmonic intonation

So, playing an unfretted string instrument such as the violin implies various possibilities for intonational expressions. In order to fully exploit the expressive potential in performance, it further requires melodic and harmonic considerations, which, indeed, pull intonation in opposite directions: in melody, towards the brightness of Pythagorean tuning, with its small diatonic semitones, high sharps and low flats; and in harmony, towards the Just tuning of vertical sonorities, giving wide diatonic semitones, low sharps and high flats in melody (Leedy & Haynes, 2001).

Translating the above into real musical situations, it means that string musicians' solo performances might be observed to come closer to Pythagorean intonation, whereas Just intonation is most likely to be a better fit in ensembles, a string quartet for instance. This could indeed explain some of the main results from Small's (1936) and Greene's (1936) studies that mainly concerned melodic intonation. As regards harmonic intonation, experienced violin instructors have discerned a need for directing string students' attention to the underlying harmony, and to how intonation can be fluid and flexible in an ensemble (e.g., Cuffman, 2016).

Now, let us turn our attention to perceived intonation. For simultaneously sounding tones (i.e., harmonic intonation), listeners can distinguish deviations from small-integer frequency ratios by the beat and roughness resulting from interactions between coinciding harmonics (Vos, 1982). Intonational deviations of successive tones (i.e., melodic intonation) are more difficult (Burns, 1999), because the beats and roughness are missing. For the current thesis, complexity and dynamics of melodic intervals will be in focus. Studies I and II, thus, explore musicians' perception and production of melodic intonation on the violin.

Also leading-tone intonation is of particular interest in these two music-psychological studies. There has been strong evidence that expressive intonation is related to tonal hierarchies. For instance, Francès' classic work, *La Perception de la Musique* (1988) comprises a series of experiments on music perception. In perhaps one of the most striking experiments, he demonstrates that the perceptual categories of pitch are not rigidly fixed but responsive to their surrounding context. To show this, he lowered the fundamental frequency of certain tones and let listeners to judge the same tones outside, and within a musical context, respectively. It was shown that the mistuning was noted by the listeners far more often in musical contexts—the flatting was noted when it was of a tone that functionally tended upward (such as a leading tone) but was ignored when it went downward with the dynamic tendency. This means, for instance, that the hierarchically less important *B* in C-major, generally anchored by the tonic *C* (see also *melodic anchoring* in Bharucha, 1984, 1996), would have a relatively large latitude for intonational expressions.

Not surprisingly, these findings conform to Small's (1936) early findings regarding "tendency tones" (see Chapter 1 and Section 3.3) and intonational variabilities of such tones in artistic violin performances. Expressive potential of the leading tones has been highlighted by practicing string musicians as well. The legendary cellist Pablo Casals, for instance, advocated the "gravitational attraction" of semitones, in which "the leading tones are raised high enough," seeking for harmonic resolution. This "organic relationship between notes in a musical context" is what formed his music-interpretational idea of "expressive intonation"[1] (Blum, 1980, p. 103).

[1] In this work, Casals' specific concept of "expressive intonation" will be denoted using quotation marks. Without quotation marks, the phrase refers to the expressive adjustment of intonation in general.

4 Aims and research questions

The primary aim of this work is to generate knowledge on classical string musicians' intonation practice. By demonstrating and making aware of musicians' and music instructors' own intonation preferences and possible underlying factors to such preferences, this compilation thesis aims for a deepened understanding and insights of what could be potentially improved in teaching of expressive intonation. In addition, this work aspires to contribute to continued interdisciplinary discourses between theorists and practitioners, and between researchers of music perception and cognition, educational science, and music performance.

This compilation thesis includes two original studies on perceived and performed intonation, followed by another two studies on pedagogical thought and practise on string intonation. In the following, research questions in each of the four studies (RQ1 – RQ4) are outlined.

Study I focuses on higher-education music students' perceptual preferences for intonation, asking two research questions:

- RQ 1.1 Does violin expertise strengthen listeners' group consensus regarding the phenomenon of "sharp leading tones"?
- RQ 1.2 Does violin expertise strengthen listeners' sensitivity to meter when judging melodic intonation?

Study II shifts its focus to professional concertmasters' (highly skilled violinists') intonation preferences, asking three research questions:

- RQ 2.1 To what extent does concertmasters' performance intonation of leading tones correspond to their perceptual preferences?
- RQ 2.2 Is the performance intonation of leading tones associated with metical position (on-beat vs. off-beat) and/or tone duration?
- RQ 2.3 How, if at all, are concertmasters' individual intonation preferences reflected in their reasonings regarding intonation?

Study III aims to understand intonation in elementary string pedagogy. It asks two research questions:

- RQ 3.1 How do string teachers understand the challenges of teaching intonation, and what are their strategies for addressing these challenges?
- RQ 3.2 How do string teachers understand the challenges of intonation for themselves as musicians, and what are their strategies for addressing these challenges?

Finally, Study IV concerns how string musicians convey their knowledge of expressive intonation, when only verbal means of pedagogical communication are possible. It asks solely one research question:

- RQ 4.1 When accounting for expressive performance, how do string musicians and pedagogues in *The Strad* talk about, explain, and made sense of intonation?

5 Methodology

The methods and material used in this work are reported in detail in the original research articles I-IV. Given my background as a classical violinist, I initiated this research project with a quantitative study in order to establish a fruitful distance to intonation as a research subject. To some extent, the quantitative approach created a lens between my personal experiences of intonation and this work.

Studies I and II follow the research tradition of psychology of music. Quantitative data of musicians' intonation preferences in perception were collected for both. For Study II, quantitative data of musicians' performed intonation were collected as well. While Study I is a perceptual study, using solely quantitative approach, Study II applies a mixed methods approach. In the latter study, the qualitative information from musicians' own reasonings regarding intonation practice and their perceptual preferences contributed to a more in-depth understanding of the quantitative dataset.

With these two first studies, I aspired to understand violin intonation as situational practice in the performance culture of Western classical music, with particular emphasis on violinists' aesthetic preferences of intonation as listeners and as performers. Such an endeavour, of course, requires adequate musical stimuli that would be stylistically familiar to the participants, to ensure ecological validity of the results. Selecting violin excerpts from the standard repertoire was therefore a given. Having the studies' focus on melodic intonation in mind, the search of the excerpts was limited to single-line melodies, preferably unaccompanied passages that included ascending semitone intervals leading up to tones that were stable in the local tonal context. After having recorded the selected excerpts with a professional solo violinist in a studio, the audio files were processed in an audio editing program, to artificially manipulate the chosen ascending semitones. The following steps differed in the two studies. They will thus be further described separately in sections 5.1 and 5.2.

In studies III and IV, qualitative approaches were applied to both. However, the sampling of data and methods of analysis differed distinctly between them. Qualitative materials were collected for Study III in terms of string teachers' written responses to a survey distributed during a Swedish national conference. The questionnaire concerned how string teachers understood challenges of intonation as teachers and as musicians, and their strategies to address those challenges. The data were analysed by using axial coding in a rather quantified manner. For Study IV, selected articles from a professional periodical were used to collect data about internationally renowned string musicians' pedagogical views on intonation in expressive performances. I was particularly interested in musicians' verbal communication of this seemingly implicit knowledge of intonation practice. Narrative analysis was the predominant method applied to this textual material.

Table 1 (on the next page) provides an overview of the various research designs, data sources, and analytical methods used in the four studies.

Table 1. Overview of the methods used in each of the four studies.

TITLE	DESIGN	DATA SOURCE			DATA ANALYSIS
		Participants	Stimuli	Addi-tional	
Study I	Listening study (two-alternative forced-choice study, fixed discrimination task)	19 violin students 19 music education students	12 violin excerpts: 6 with metrical accent, 6 without metrical accent. 3 intonation variants: 110 cents 90 cents 70 cents		Quantitative analysis (Chi^2 test, Linear mixed logistic regression)
Study II	Performance study + Listening study + Semi-structured interview	6 professional concertmasters	8 violin excerpts 13 selectable semitone sizes between 20–140 cents	Verbal protocols from the listening study Interview material	Mixed methods seeking dynamic inter-dependence between the two strands of data (repeated measures correlation & thematic analysis)
Study III	Survey study with two pairs of open-ended questions	95 string teachers Main instrument: violin 59 viola 6 cello 16 double bass 3			Initial coding & axial coding
Study IV	Text study, using published material from professional periodical	41 articles in *The Strad* about intonation and expressive performance String instrument concerned: violin in 18 articles viola in 3 articles cello in 15 articles			Narrative analysis with a discourse perspective

5.1 A listening study (Study I)

Study I is a perceptual study, using solely quantitative approach. The nature of quantitative research could be described in broad terms "as entailing the collection of numerical data, as exhibiting a view of the relationship between theory and research as deductive" (Bryman, 2012, p. 160). To collect numerical data on perception of tuning, there seems to be a long tradition of using two-alternative forced-choice (2AFC) among music psychologists (see, e.g., Burns & Campbell, 1994; Houtsma, 1968; Lynch et al., 1991; Micheyl et al., 2006; Zatorre, 1983). This design enables isolation of a certain effect from the others, which appears appropriate for the purpose of Study I that involves discrimination of intonation.

Twelve violin excerpts were selected, each of which included ascending semitone intervals consisting of a tonally "unstable" tone and a "stable" one. The semitone interval either occurred between the seventh scale degree and the tonic or between the raised fourth scale degree and the dominant, or involved chromatic embellishments of successive chord tones present in the melody. In six cases, the first "unstable" tone was metrically accented (i.e. occurring on a beat) and in six cases it was unaccented. Three intonation variants for each excerpt were created, yielding ascending semitones of 110, 90, and 70 cents below the stable tone. We used a fixed discrimination task. One major argument for using this method is the possibility of keeping listeners free from memory constraints (Burns, 1999). Therefore, we kept the excerpts as short as it could be achieved, while still maintaining substantial harmonic and musical content.

As shown in Table 1, 38 Swedish higher-education music students participated in the 2AFC study. They were evenly divided into two groups of violin students and students of music education, in order to address the two research questions concerning violin expertise. In a listening study designed using the stimulus presentation software SuperLab 6, the participants were asked to listen to pairs of excerpts (that differed only in the size of semitones) and to choose the intonation variant that they preferred (see Appendix A). By involving two participant groups differing distinctively in their instrumental expertise, we were provided the opportunity of investigating the proposed research questions concerning violin expertise.

5.2 A listening and performance study (Study II)

Study II combines quantitative and qualitative research strategies. The natural scientific model with its focus on behaviour is here given a deepened meaning. Previous studies within the field of intonation have mostly taken quantitative approaches, but an interesting exception was to be found in Yarbrough and Ballard's (1990) study in which qualitative feedback from the participants were informally reported. Hence, we thought that some insights from musicians and their own reasonings surrounding the preferred intonation might contribute to a more rounded view of the issue. Furthermore, selection of highly skilled violinists, in this case six professional concertmasters in Sweden (see Table 1), was crucial to Study II due to the fact that studies on skills related to pitch had rarely been studied with the most advanced performers (Morrison & Fyk, 2002).

We reused eight (two thirds) of the pre-recorded audio files from the previous study, including only ascending semitones leading up to the tonic or the dominant in the local tonal context (see Appendix B for scores sent to participants). Leading tones with longer duration were preferable, in order to increase reliability of the results, and thus the excerpts with chordal embellishments used in Study I were left out here. The data associated with both research strategies were collected concurrently, in terms of an individual combined session of recordings of each participant's performance intonation, their individual assessments of intonation in a listening study (see Appendix C), and a semi-structured interview (see Appendix D). The qualitative dataset consisted of verbal protocols during the listening study and the interview material. The two datasets were analysed separately, before being integrated in a way that they "become interdependent in reaching a common theoretical understanding [and] investigative goal" (Bazeley, 2024, p. 225). Despite the small number of participants, the complexity and quality of the data were thus expected to deliver adequate answers to the research questions. In addition, the two sets of findings were expected to help identifying those parts of musicians' knowledge of intonation that might be implicit, and thus practised intuitively.

5.3 A survey study (Study III)

Qualitative data typically take the form of a large corpus of unstructured textual material, and there are various approaches to analysing the data. In Study III, the data derived from 95 string teachers' written responses to a questionnaire containing two pairs of open-ended questions (see Appendix E). Two of the questions were about how the participants, as teachers and musicians, understood the challenge of intonation, while the accompanying questions acquired information about their concrete strategies to address those challenges.

On the one hand, a Swedish national conference of string teachers provided possibilities to collect data from a larger and clearly defined participant group. On the other hand, the written answers were usually brief, and any additional data for deepened understanding of the string teachers' experiences and thoughts were difficult to achieve. Given this nature of the material, we applied coding: an initial coding was followed by axial coding "to determine which [codes] in the research are the dominant ones and which are the less important ones," and to "reorganize the data set: synonyms are crossed out, redundant codes are removed and the best representative codes are selected" (Boeije, 2010, p. 109). During this process, the initial codes were condensed into a smaller number of categories. This method "aims to link categories with subcategories and asks how they are related" (Charmaz, 2014, p. 148). We additionally sought understanding of such relationships through discussions of both authors' independent coding processes, reflecting on the agreements and disagreements we had on the labelling of the categories.

5.4 A text study (Study IV)

The text corpus of Study IV consisted of 41 selected articles from the professional periodical *The Strad*. Selection of the articles was based on a digital search on the website www.thestrad.com, combining two keywords, "expressive" and "intonation." A generic purposive sampling approach (Bryman, 2012) was applied with the intention to focus on prominent musicians' verbal communication surrounding intonation in cases where expressivity was likewise mentioned in the article. Subsequently, the

qualitative nature of the textual material was approached through narrative analysis (Riessman, 2008), seeking deepened understanding of musicians' personal experiences of intonation, how they account for, explain, and make sense of intonation in expressive contexts for pedagogical purposes. Musicians' narratives were approached with a discourse perspective, in order to distinguish their shared views and what differentiate between these views.

In the text corpus, there were a handful of articles authored by reviews editors at *The Strad*. In these cases, legendary (and deceased) musicians' experiences and views of intonation were being retold and restoried by the authors. According to Bryman (2012), this is a common issue when using mass-media outputs. However, these articles provided rich and interesting information well in accordance with the purpose of the study. In fact, they did not only address the question of how legendary musicians make sense of intonation practice in expressive performance, but also how some of these musicians may have influenced the pedagogy of expressive intonation, adding a historical point of view. Furthermore, the use of mass-media outputs "may require considerable awareness of contextual factors" (Bryman, 2012, p. 553). My preunderstanding of the musical culture of string performance was indeed advantageous, especially in cases where awareness of the implied messages in musicians' pedagogical communication was required. A narrative approach to this textual material was therefore deemed an appropriate method.

5.5 Ethical considerations

All studies included in this doctoral thesis were carried out in accordance with the ethical guidelines of the Swedish Research Council (2017). In Studies I–III, all musicians (higher education music students in Study I, professional concertmasters in Study II, and string teachers in Study III) participated voluntarily and signed an informed consent that contained necessary information about the study in question and details about anonymous participation and confidential handling of the collected data.

Given the case-study design of Study II, each of the concertmasters' results were analysed in a detailed manner, and anonymously. However, as commonly known, the community of classical music tends to be small, and musicians are usually acquainted with each other. Hence, it required some efforts to keep all

participants' anonymity intact. Equally important was to help the participating musicians to understand the necessity of confidentiality in research, because they are normally used to have their hard work and efforts rightfully acknowledged.

Studies I and II additionally required audio recordings of the selected excerpts. An informed consent was, therefore, also obtained from the solo violinist that voluntarily agreed to help with the recordings. In this consent, we particularly ensured limited distribution of the audio files that would be used only for the purpose of this doctoral project.

The methodological approach in Study IV differed slightly from the others, due to its use of already published textual material. It was thus not necessary (nor realistic) to obtain consent from each of the musicians whose statements were analysed in the sampled material. Although musicians were not studied as individuals but rather approached as groups based on their shared understandings or different approaches, they were all kept anonymous in the results (except those from the past). In this case, I found it to be important to consider ethical consequences in relation to musicians' personal integrity as professionals, given that many of them are internationally reputed. All surveyed articles were coded in this study. However, in order to provide analytical transparency required for scientific work, a citation of these articles is provided as supplemental material of this publication.

6 Results

Results of the four studies included in this work are summarized below. More details, including tables and figures, are reported in the original research articles I-IV.

6.1 Study I: Intonation perceived by violin students

In Study I, we focused on the phenomenon of "sharp leading tones", suggesting that Casals' views regarding intonation practice might also be consistent with common perceptual preferences among present-day classical string instrumentalists. Accordingly, RQ 1.1 was whether violin expertise strengthens listeners' group consensus regarding preferred melodic intonation in this particular manner. This question was addressed by comparing the perceptual intonation preferences of music students with and without violin expertise. We hypothesized that greater instrumental expertise might in general result in a stronger preference for sharp leading-tone intonation.

Contrary to our hypothesis, greater instrumental expertise did not always result in stronger overall preference for sharp leading-tone intonation. In particular, violin students were not more likely than music education students to prefer the sharpest 70-cent variant in this study, when compared to the 110- and 90-cent intervals. What we did find, however, was that both groups preferred the 90-cent variant to the 110 cents variants, and there was greater consensus about this among the violin students. In other words, preference of the 90 cents interval over the 110-cent variant was not contextually based, and it appeared regardless of music students' instrumental background.

RQ 1.2 was whether violin expertise strengthens listeners' sensitivity to meter when judging melodic intonation. We hypothesized that greater instrumental

expertise might bring about a stronger aesthetic preference toward sharper intonation in metrically unstressed locations.

The results were in accordance with out hypothesis, suggesting an expertise-related connection between intonation preference and meter. For the music education students, we were unable to predict intonation preference by observing whether the unstable tones occurred on metrical accents or not. For the violin students, however, such an association did seem to exist: our results suggest a stronger preference for the sharpest leading tone (i.e., the 70-cent variant) in the absence of metrical accent, that is, when unstable tone was off-beat. In effect, this is to prefer an expressive intonation that colours the music while not challenging the harmonic structure at metrically salient tones.

6.2 Study II: Intonation perceived and performed by concertmasters

Study II continued to explore musicians' preferences of leading-tone intonation for the solo violin. Given the integrative approach of the two datasets, results of Study II will be presented in this order: RQ 2.1–RQ 2.3–RQ 2.2–RQ 2.3.

RQ 2.1 asked to what extent our six concertmasters' performance intonation corresponds to their perceptual preferences. Overall, in the listening part of the study, they typically did not just accept a single variant of leading-tone intonation, but showed wider ranges of accepted semitone sizes between the leading tone and the following stable tone. The midpoints of these violinists' ranges were somewhere between 80 and 90 cents. When performing, their individual average semitone intonations fell between 78 and 89 cents. In other words, the concertmasters' grand means of performed semitone sizes seemed to conform to the general picture shown in their perceptual preferences, and they generally preferred a semitone intonation that was sharper than both the equal tempered and the Pythagorean intonation.

As regards RQ 2.3 concerning whether and how concertmasters' intonation preferences in perception and in performance were reflected in their own reasonings, the qualitative results similarly showed a shared understanding of what is generally considered good intonation of leading tones. The term "old

school" was explicitly used by concertmasters when explaining the traditionally preferred sharp leading-tone intonation. However, they all considered intonation to be personal and flexible for expressive purposes depending on musical situations. As a whole, these musicians' individual intonational ideals reflected in the qualitative material go well along with their performance intonation, despite certain discrepancies revealed between self-assessments and their actual performance intonation.

RQ 2.2 addressed whether the participants' performance intonation was associated with tone duration and/or metrical position. Apart from some individual differences, there was a moderate common within-individual association between performed duration of leading tone and performed semitone size. On the whole, a semitone size as tight as 60 cents was not at all rare in concertmasters' performances, but intonation sharper than 80 cents rarely occurred in tones with a duration of over one second. In addition, several participants tended to reduce the semitone size when the leading tone was off-beat. Hence, we tentatively concluded that sharp intonation of leading tones is often associated with short tone duration and/or off-beat notes in concertmasters' solo performances. However, there may be room for individual styles and preferences that resist such trends.

In order to integrate the qualitative results into this part of the results and, again, addressing RQ 2.3, we noted that temporal aspects of intonation practice were not explicitly mentioned by the participants in the interview or during the listening study. Hence, these findings suggest that temporal influences on expressive intonation are embodied, often representing implicit knowledge among skilled musicians. To put it plainly, these violinists reacted instinctively to the metrical context when adjusting intonation.

6.3 Study III: Intonation in elementary string pedagogy

In Study III, we examined 1) how string teachers understand the challenges of teaching intonation and how they address these challenges, and 2) how they understand the challenges of intonation as musicians and their strategies to address those challenges.

Five categories of challenges in teaching intonation were identified in string teachers' written questionnaire responses. *Hearing and listening*: there was an understanding that teaching intonation is not only about to avoid mistakes, but rather about helping pupils develop their own inner standards for appropriate intonation. *Physiological aspects*: the challenges are linked to basic physiological aspects of playing technique. *Understanding*: there were, for instance, problems that pupils find intonation too "abstract" to understand, because it "depends on context". *Psychological aspects*: importance of finding balance between correcting and letting pupils play on, and to customize demands according to each pupil's learning progress. *Resources*: pupils' insufficient resources in terms of too little time spent with the teacher weekly, and time spent on their own practice, as well as the support they are getting at home.

Four larger categories of approaches could be recognized to address the above challenges. Firstly, some *general approaches* included advising pupils to listen, and to find a relaxing posture. Secondly, *pupil/student activities* such as letting pupils explore or adjust intonation in relation to the open strings, and strengthening pupils' own internal sense of proper intonation in different ways. The third category was *teacher activities* in terms of verbal explanation, piano accompaniment, playing together with the pupil, or demonstrating "good" and "wrong" intonation. Finally, some teachers also used *physical tools* such as finger board markers or recordings.

As for the participants' own musicianship, we observed mainly four categories. *Contextual aspects* was identified as the most pronounced one. Apart from the variety of string teachers' descriptions, the overall picture was that intonation was seen to be critically dependent on the presence of other musicians and/or the harmonic contexts created thereby. The second pronounce category was *Instrumental technique*, followed by *Attitudes and habits* that involves these teachers' own practice. For the last category, *Everyday practice*, it concerns the practical challenges for the teachers of finding time to practice intonation after teaching.

In order to address intonation challenges as a musician, the string teachers' strategies could be grouped into three categories: *General approaches*, *Preparatory work*, and *Practicing repertoire*. Interestingly, these strategies shared some commonalities with the participants' pedagogical strategies. However, a notable addition to their general approaches is the emphasis of playing with others. Quite expectedly, the teachers' strategies of dealing with

intonation could otherwise be roughly divided into two groups, one involving basic techniques and one focusing on the specific repertoire.

6.4 Study IV: Pedagogy of the fine art of intonation

The aim of Study IV was to investigate how prominent string musicians and pedagogues in *The Strad* talk about, explain, and make sense of performance intonation when expressivity is likewise addressed. The results from narrative analysis of the textual material showed mainly four different ways of approaching this topic in musicians' pedagogical communication.

In the first group of seven articles, string musicians consistently referred to Pablo Casals' concept of "expressive intonation" in order to explain the expressive potential of intonation in performance. Not too surprising yet interesting to note was that cellists were over-represented in this group. Casals' "expressive intonation" seemed to be understood and interpreted rather individually. The only non-cellist within the group, a violinist, was the only one that depicted a genre-based approach to intonation.

In the second group of eleven articles, musicians considered the link between intonation and expressivity as obvious. They did not seem particularly interested in explaining "the prevalent and obvious", perhaps due to their expectations that students already possessed such knowledge. Instead, the expressive characteristics of intonation were commonly implied between the lines. However, in some cases, such communication appeared to cause confusions on the way.

Musicians in the third group with five articles seemed rather irresolute. Despite the clear focus of expressivity in performance, covering the intimate relationships between various techniques and musical expression, it was difficult to interpret the musicians' pedagogical communication. They neither dismissed nor acknowledged intonation as an expressive device. At the same time, there was a sense of implying a certain connection between intonation and expressiveness.

The largest group consisted of eighteen articles. Here, the topic of expressive intonation was completely absent despite the two keywords being literally present. The strategy of using metaphors was common among musicians, and

intonation could also be approached practically as a physical element to conquer in challenging pieces. The expressive potential of intonation did not seem to be a given in these musicians' pedagogical communication.

Overall, the discourse of articles in *The Strad* conveyed a consensus on the importance of intonation in expressive performance. However, compared to intonation, the current material also revealed several other aspects in performance that were more frequently and clearly conveyed as expressive devices by string musicians in *The Strad*.

7 Discussion and conclusions

The aim of this compilation thesis was to investigate the role of intonation in expressive performance of Western classical music, how the knowledge of intonation practice is conveyed to younger generations, and what could be potentially improved in string pedagogy in this regard.

The findings in this work suggest that intonation is practised as an expressive device in violin performance. Practising musicians are usually confident that intonation helps articulating personal interpretations of the music, thus giving stylistic and music-contextual considerations to their own intonation practice. However, due to the partly intuitive manifestation of expressive intonation, it is a challenge for music teachers to convey such expert knowledge in pedagogical communication. Music-psychological approaches were shown to provide possibilities of an increased awareness of the intuitive aspects of intonation practice, thereby disclosing potential for improved teaching of expressive adjustments of intonation.

Given that performance skills and good judgment of appropriate intonation are commonly expected at higher music education, susceptibility to the intuition of "good" intonation at an early stage of pupils' formal instrumental music education is essential to their continuing developments as musicians. Hence, the findings additionally suggest the importance of enhanced support in the work of elementary string teachers.

7.1 Conventions vs. Personal expression

Studies I and II concerned violinists' intonation preferences for leading tones. The findings in Study II with six concertmasters are in line with previous research, suggesting that skilled violinists' intonation preferences vary within and between individuals in their performances (Greene, 1936; Small, 1936;

Loosen, 1993; Geringer, 2018). Similar variability seems to occur also in the participants' perceptual preferences of intonation. At the same time, the results reflect a consensus regarding a generally accepted intonational convention within what has been called "mainstream performance style" (Fabian, 2015). Concertmasters in the study demonstrated a conventionally performed range between approximately 80 to 90 cents for the interval between a leading tone and its neighbouring stable tone. Their performed intonation was thus generally sharper than any of the three commonly referenced systems (i.e., the Equal tempered, the Just, and the Pythagorean intonations). Given the contextually dependent variability of intonation practice, and that intonational expressions tend to be deeply personal (a view also shared by these participants), it was rather compelling to find such a performance range on a group level. Even more interesting was how well this range conformed to the midpoints of concertmasters' preferred ranges in the listening study. To the best of our knowledge, this is the first empirical study showing such a correspondence between perceptual judgments of intonation and performed intonation. Morrison and Fyk (2002) proposed that "clearer relationships among the various skills related to pitch will be found by concentrating future research efforts on the most advanced performers" (p. 186). This was indeed the case in our investigation. However, more research on professional performers is needed to better understand whether such a clearer relationship between the two domains solely depends on high skill level in performance.

Unlike Study II, the purpose of Study I was to compare perceptual preferences of intonation between two groups of music majors that differed in instrumental expertise. The data was thus analysed only on a group level. Nevertheless, I informally studied the data of each of the 19 violin majors. Combined with verbal feedback from these violinists after the listening study, I realised that also these young individuals had personal preferences and ideals concerning intonation, however uncertain they might have felt about their perceptual preferences in certain musical contexts. This indeed suggests that individual preference of intonation is a continuous development that starts long before higher music education. However, it is an ongoing process, during which the violin majors need guidance in search for their own personal styles. On a group level, these violin majors' results showed a pronounced preference for 90-cent intonation, conforming to what is commonly considered a professional standard of violin soloists' performance intonation (e.g., Small, 1936; Geringer, 2018). Indeed, in a previous study with beginning and intermediate wind players, a tendency of performing sharper intonation than the Equal-tempered intonation was reported to emerge already over the first four years of

performance study (Yarbrough et al., 1995). Hence, it would be logical to assume that musicians' perceptual intonation preferences are developed parallel to their enculturation into conventional intonation practice.

The interplay between individual's perceptual intonation preferences and the convention is interesting, indeed. This was particularly transparent during the listening experiment in Study II, when all concertmasters emphasised their awareness of the prevalent and/or the standard intonation, before approving a seemly deviant option or disapproving a conventional one. Apparently, they all took a personal stand for their own artistic ideals regarding intonation in relation to conventional aspects of performance practice that entail stylistic and contextual considerations. Given the conformity between concertmasters' perceptual judgments of intonation and their average semitone size in performance, the results indeed suggest an artistic maturity and an ability to achieve the intended expressiveness through leading-tone intonation (on latitude for intonational expressions, see Section 3.5 Leading-tone intonation). An informal though interesting observation is that these participants' individual applications of intonation were perceived by me, an expert listener, as personal styles and interpretations of the music.

However conscious these intonational choices may have seemed, parts of these decisions made by highly skilled violinists also appear to be intuitive, thus being governed by conventional aspects of performance practice. This was noticeable especially in cases where some of the concertmasters emphasised personal and deviant ideals according to their verbal protocols, but their performed intonation showed rather conventional practice, after all. Furthermore, we saw already in Study I a connection between violin majors' perceptual preference of intonation and meter, and that such connection was related to their instrumental expertise. In Study II, the influence of meter was further confirmed together with that of tone duration. In addition, such expert knowledge of accomplished violinists was revealed to be predominantly embodied and implicit. This resonates with how recent research in music cognition has highlighted understanding rhythm in terms of embodied cognition (for an overview, see Honig, 2013). A relevant reflection in this context is that metrical aspects are merely a small part of what musicians call "the musical context." Although the musical context is frequently referred to as a major factor for fine adjustments of intonation, the relationship between meter and intonation is rarely explained in an intelligible and explicit manner by musicians.

As discussed in Chapter 1 and Section 2.1, Seashore (1938) proposed that "artistic expression of feeling in music consists in esthetic deviation from the regular" (p. 9). The current discussion suggests that "the regular" may indeed include various kinds of standards/conventions/norms, into which musicians have been cultivated through years of training. Artistic expression in music thus consists of deviating from whatever is considered prevalent in a current performance culture. Such a culture may concern the actual musical setting, the time period and/or the genre of the piece, a long-lasting performance style or just a transient popular trend, the local musical context and/or theoretical aspects such as a formal tuning system. All such aspects may contribute to a conventional backdrop, against which the musicians then make their expressive gestures in terms of individual intonational choices.

An increased awareness of such intuitive aspects of performance intonation, and insights into the dynamic interplay between personal expression and the conventions, indeed, evoke pedagogical thoughts for higher music education. Equally interesting is the development of young string players' intuition for appropriate intonation and their enculturation into conventional intonation practices. In the next section, these issues will be discussed from a string-pedagogical point of view, alongside challenges that might be involved in teaching.

7.2 Pedagogical challenges

Study III addressed mainly teaching beginning and intermediate string players' intonation. Many of the surveyed string teachers emphasised the amount of time necessary for helping their pupils to hear and distinguish intonational qualities, so that they could eventually develop an advanced understating of "good intonation" in accordance with conventional practice. In string teachers' strategies to address the challenges in teaching intonation, a great deal of creativity and ingenuity emerged in the material. Indeed, cultivating the idea of good intonation requires persistent and well-instructed practice, and a large amount of patience. It is, therefore, essential that these strategies are well balanced between the serious pursuit of skill acquisition of intonation and the fun in making music. Maintaining the fun and adapting to children's own

learning styles is the key to make learning of a musical instrument more efficient (Calissendorff, 2005).

Interesting to add to the current discussion is that almost 90% of these Swedish string instructors were teaching within the Nordic system of Schools of Music and Performing Arts (SMPAs, Swed. *Kulturskola*, "cultural school"). Instead of meeting the need for time actually required to developing childrens' intuition for conventional practice, the enrolled pupils at SMPAs are generally provided only twenty minutes per lesson and week for individual instructions on the instrument. From a societal perspective, this entails that only families with financial capability or with musically active parents that might properly be able to meet children's needs for developing musical skills. Such inequality has been discussed by a number of Swedish researchers, considering it as a result of the "closed system of music education" (Bladh, 2002; Bouij, 1998; Brändström & Wiklund, 1995; Di Lorenzo Tillborg, 2021; Jeppsson & Lindgren, 2018; Lindgren, 2024). From a string-pedagogical viewpoint, longer instrumental lessons would provide children the possibility of quickly and effectively improving themselves while being instructed. In addition, such instructions are also situated (musically and technically) and better individually adapted. In the long run, the lack of resources for children's instrumental music education, indeed, affects the quality of higher music education and the accessibility to music and culture among the public, making this an urgent political issue.

Study IV investigated distinguished string performers' verbal communication concerning intonation that was documented in the professional periodical *The Strad*. Some of the musicians had explicit ideas of the connection between intonation and expressivity, for instance in terms of Casals' notion of "expressive intonation," but others (in 12 of the 41 articles) appeared to take this connection for granted and treated it only implicitly. Apparently, these latter musicians expected the targeted readers of *The Strad* and advanced string players to be cultivated into conventional practice, including that of intonation. Given the sampled material was limited to merely explicit use of the combined keywords, intonation and expressivity, occurrence of this attitude among musicians is likely to be more prevalent than shown in the study.

More important, however, is the evidently difficult challenge of communicating implicit and embodied knowledge of expressive intonation. The results in Study IV were in line with previous studies showing that teaching expressivity is frequently not explicit in music lessons, and that teaching tends to focus on technique (for a review, see Hallam, 2010). The thorny balancing act between emphasising expressive and technical aspects in

performance was rather obvious when some musicians (in 5 of the 41 articles) seemed unclear about whether they intended to address intonation as merely a technique or an expressive means. In a recent study, McPherson and Blackwell (2024) analysed experienced collegiate instrumental teachers' verbal feedback when giving lessons. The authors concluded that "[m]aking learning objectives explicit and discussing success criteria are essential skills for teachers to develop." Referring to an earlier study (McPherson et al., 2022), they further argued that "[w]hatever the verbal or performance-related feedback provided by a teacher, an important element of this process is that both the teacher and the student possess a shared understanding of what the goal might sound like and the process that will help the student reach this goal" (McPherson & Blackwell, 2024, p. 15). As was indicated above regarding Study I, violin majors need guidance in search for their own performance styles and personal expressions. Effective communication of expert knowledge on intonation, whether it is implicit or explicit, is therefore essential for teaching of expressive performance.

In order to achieve effective communication in teaching of expressive performance, it was suggested in Study IV that both accurate vocabulary and artistic insights regarding performance practice are important. Study IV thus encouraged interdisciplinary collaborations between researchers and practitioners. This view resonates well with Williamon's (2014) conclusion that building bridges is vital and timely for the future both of music education and of research into music learning, teaching, and performing. However, as all interdisciplinary collaborations, also such an endeavour requires progressive minds and mutual respect. It is thus not likely to escape resistance. Discussing the evolving teaching tradition of Western art music, Fabian (2015) explains that "[t]he master-apprentice model and prestige of educational institutions ensured that change was slow and seemingly imperceptible. Thus emerged what the musicological literature tends to call 'mainstream performance' (MSP) style" (p. 26). In a sense, this is also a closed system—constantly pushing back other influences—that has been prevalent for more than a century.

It is telling that some authors use the term "conservatory standard" to refer to the conventional practice of intonation in the 20th century Western classical music (Leedy & Haynes, 2001). In terms of helping instrument majors to find their personal expressive style, the present work points toward a challenge for the teachers to balance between two tasks. On the one hand, they need to pass on the tradition of the "conservatory standard", but on the other, it is as crucial

that they recognise and acknowledge individual artistic qualities, encouraging the development of personal expression.

To wrap up this part of the discussion, it seems that we would have to go back to where we started. Knowing that string instruction in higher music education relies heavily on the early cultivation of children's musical intuition and good taste for appropriate intonation, the responsibility of instrumental teachers with beginning and intermediate string players seems rather extensive. They have to build, strengthen, and then further develop a culture-specific intuition for intonation practice in their pupils. In my view, this includes helping learners to 1) understand the concept of intonation, 2) increase their awareness of intonation during performance, 3) automatise their intonational adjustments, and finally, 4) develop the intuition for appropriate intonation within a given musical context. It is thus essential that teachers are well supported in this work, so that young string players at artistically more advanced levels can better focus on developing their own concepts of expressive intonation and the technical proficiency required to achieve that goal.

7.3 Limitations and future studies

As already clarified in Chapter 1, this compilation thesis is positioned at the intersection of predominantly two research fields, psychology of music and music education (more specifically, string pedagogy). Nevertheless, the work involves (and has to involve) some peripheral disciplines as well, for example, performance research and musicology. It is thus interdisciplinary in its nature.

The main criticism of the music-psychological approach to musical performance has often been that it is limited to what it can measure and test. Even when such studies concern technical and stylistic differences, practising musicians might feel that the results do not necessarily provide penetrating new insights (see McCaleb, 2014). In the case of intonation, given its fluid nature in practice, the accuracy indicated by cent as measurement may be considered unrealistic, perhaps even undesirable by musicians. However, for the purpose of this thesis, measuring in cents has been useful for communicating about musicians' intonation preferences, in perception and in performance. In addition, it particularly helped to visualise some intuitive aspects of performance intonation, also revealing some discrepancies between musicians'

self-assessments and their actual performance practices. From my point of view as a classical violinist and a string pedagogue, this provides new insights that are valuable both in teaching and in performance. Therefore, I see no reason why music cannot use science (in this case a music-psychological approach) for its own benefit to obtain further understanding and mastery of expressive techniques, such as intonation.

In the present work, exact measurements of string intonation practice have been delimited to measuring intonation of the leading tones (other approaches might well be possible, such as measuring intonational variability in the size of major and minor thirds). Apart from this, there are also other limitations in each of the four studies that should be acknowledged.

As the focus of Study I was group tendencies in students' perceptual intonation preferences, the quantitative methods left individual differences within each group rather unexplored. That was what inspired the case-study design of Study II in which both quantitative and qualitative data were used in a mixed-methods fashion. However, the selected violin excerpts in both studies were limited in many respects. For instance, we were not able to investigate aspects in violinists' intonation preferences that concerned genre and musical style, or technical strategies that might be involved in performance intonation. Violinists' sensitivity to metrical structure shown in both studies clearly point to a contextual understanding of performance intonation. Given that metrical aspects are just a small part of the musical structure, there can reasonably be other elements and variables affecting musicians' intonation preferences, either in interaction with one another or independently. Hence, music-contextual influences on performance intonation are just partially disclosed in this work. Furthermore, there is a need for future studies to further explore the relationship between professional musicians' perceptual assessments of intonation and their intonation in performance.

As we already discussed earlier, young string musicians' journey before being enrolled to higher music education is long. Their development as instrumentalists includes different proficiency levels, from basic beginner's level to artistically advanced pre-college level. Study III was limited in the sense that it was not able to identify the various string-pedagogical strategies in relation to learners' proficiency levels, neither technically nor musically. Additionally, the survey answers from the string teachers were usually brief, without the opportunity to obtain additional data for deepened understanding of their teaching experiences. To cope with the full complexity, future efforts may find more suitable research designs to systematically approach the topic of teaching intonation below college level. Equally important is to explore how

intuitive aspects of intonation can be effectively trained at an early stage of string instrumentalists' musical journey.

From previous research, we know that various strategies are used by string pedagogues to convey their messages when teaching expressive performance (Barten, 1998; Ha, 2015; Nielsen, 2006; Rosenberg & Trusheim, 1989). In Study IV, only verbal communications surrounding intonation (as documented in written form) were investigated. Strategies that combine verbal communication with tactile or other face-to-face pedagogical methods anticipated in real teaching situations were not available to be communicated through the medium of the professional journal. Given that the main focus of the articles in *The Strad* could be something else than expressive potential of intonation, the picture that emerged from the articles included in this study may not be entirely rounded.

Finally, it is important to keep in mind that this doctoral project was largely conducted in a Swedish context: Study I with Swedish higher-education music students, Study II with concertmasters employed in Swedish professional orchestras, and Study III with string teachers working in Sweden. Study IV was the only one that shed an international light on the topic. However, considering the international educational backgrounds of the concertmasters in Study II, the intonation culture described in the first two studies appears to be an international phenomenon. Still, geographical influences of intonation preferences would, indeed, be interesting to explore, even within the performance culture of Western art music.

7.4 Concluding remarks

This work demonstrated that string intonation is individually and contextually applied by professional musicians as an expressive device in performance. The interdisciplinary approach has been particularly fruitful in terms of new insights regarding the implicit aspects of perceived and performed intonation. These insights may support increased creativity in teaching and offer conceptual reference points for string teachers at pre-college levels and in higher music education. Increased awareness of what makes performance expressive additionally supports potential improvements of musicians' own performance practice.

In terms of facilitating instrument majors' artistic development, finding their own performance styles, the present work points to the importance of diversified performance and teaching styles and specialties among the teaching staff in higher music education. This view is, indeed, in accordance with the prevailing trend that increasingly allows permissive attitudes in string performance. According to Milsom (2003), clear distinction of styles in terms of the stereotypical "historical-versus-mainstream" divide has become hard to uphold since the early twenty-first century. Also, Fabian (2015) advocates for a more balanced, humble, and open-ended approach in performance. Encouraging instrument majors to study for teachers with various specialties and tastes could potentially help students to—technically as well as artistically—become more rounded as musicians. Nielsen (2006) similarly notes that it is important for students to be able to observe different approaches to music-making in their study environment. In his view, to learn and be inspired from many potential masters gives the student possibilities to develop their personal styles.

In order to fully comprehend the fine art of intonation, there is however another challenge for higher music education to overcome. In Studies I and II, theoretical understanding and measurements of string intonation were shown to be usefultoobtain further understanding of the topic. Insights gained from the collective findings of this work suggest that music theory and tuning systems need to be introduced to music majors and music education students in a more integrated manner. Most importantly, the emphasis in teaching music theory needs to be approached in a sense that it highlights the practical and artistic values of theoretical knowledge in performance. In the long term, a practical approach of tuning systems could result in more insightful teaching of string intonation at all levels of the instrumental music education.

In achieving personal expression, coexistence of "the regular" (Seashore, 1938) and the leeway of intonation practice in string performance is, indeed, crucial. Thanks to the mathematical incompatibilities in tuning—e.g., the Pythagorean comma—string players are provided an artistic latitude to deviate from rigid tuning systems or various performance conventions for their own intonational interpretations and thus personal expression in performance. This may well hold part of the inherent beauty that makes musical experiences alive, honest, and magical, for both the audience and the performer(s). While my hope in this work has been to bridge the gap between the joy of expressive performance and intelligible conception of intonation, I hope my readers (listeners, performers, and music educators alike) will continue to be touched and fascinated by the mysteries of musical expressions in string performance.

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Appendices

Appendix A: Information provided in SuperLab (Study I)

INTRODUCTIONS

Thank you for participating in this study on intonation in performance!
We will start with two practice trials as a warm-up.

Each trial will let you compare two versions of performed intonation for the same short violin excerpt. The two versions only differ in the intonation of some critical notes. Otherwise, they are identical. Between the two versions, there will be a short break of 1 s.

Your task is to choose the intonation that you prefer:
Please press 1 if you like the 1st one better.
Please press 2 if you like the 2nd one better.
Wait until you have heard both versions before responding.

The next trial will then follow immediately after your response.

Even if you experience some of the differences to be a little difficult to hear, please try to respond intuitively. We are not interested in evaluating your aural skills. Instead, we want to learn about your intonation preferences.

When you are ready, please press any key to begin with the practice trials.

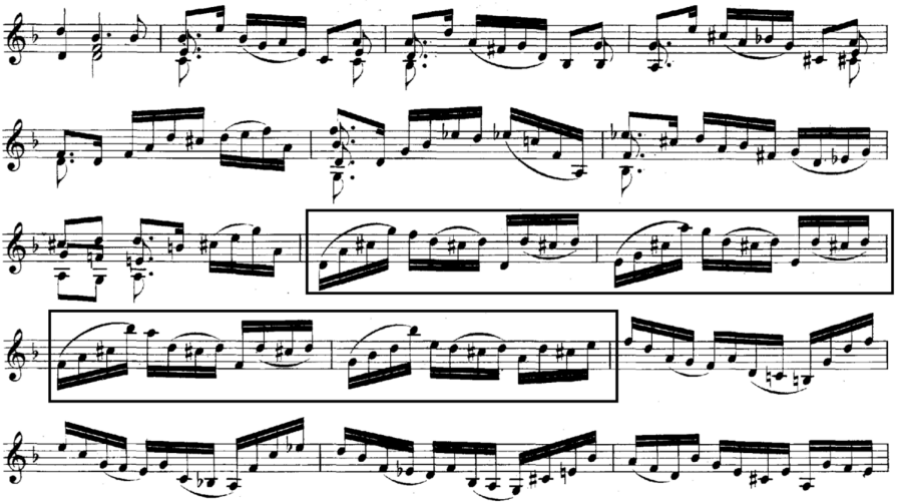
BREAK QUESTION

You have just finished the two practice trials.
If you have any questions, please ask now. Otherwise, you can proceed to the main experiment.
In the main experiment, you will hear 36 similar pairs as before.
When you are ready, please press any key to begin the experiment.

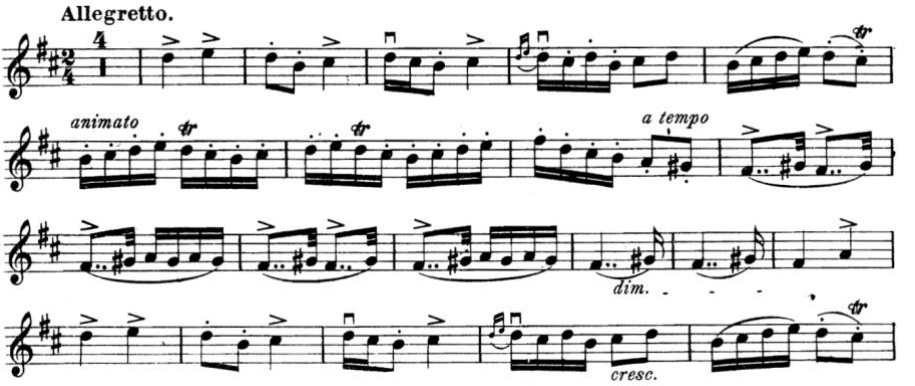
FINAL NOTES

You have now completed the whole experiment.
Thank you for your participation!

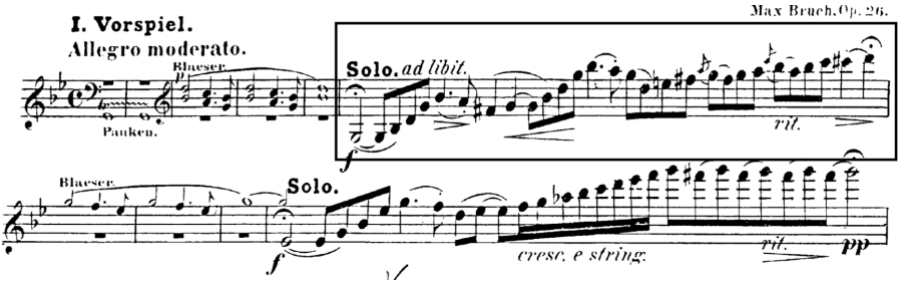
Bach – Violin partita in d minor, from Chaconne (bars 216-219)



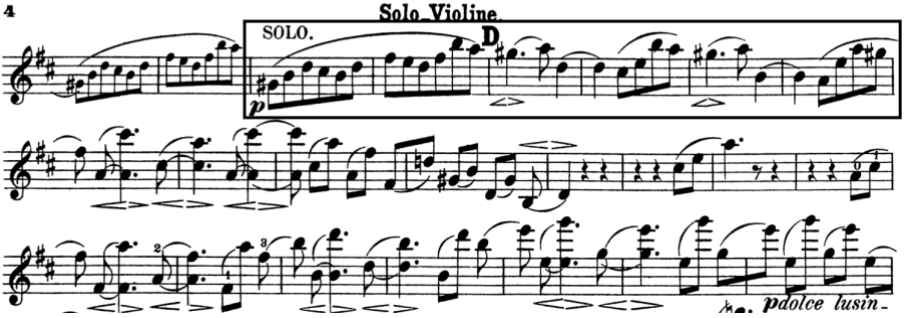
Couperin-Kreisler – from Chanson Louis XIII and Pavane (bars 6-18 in Pavane), D major



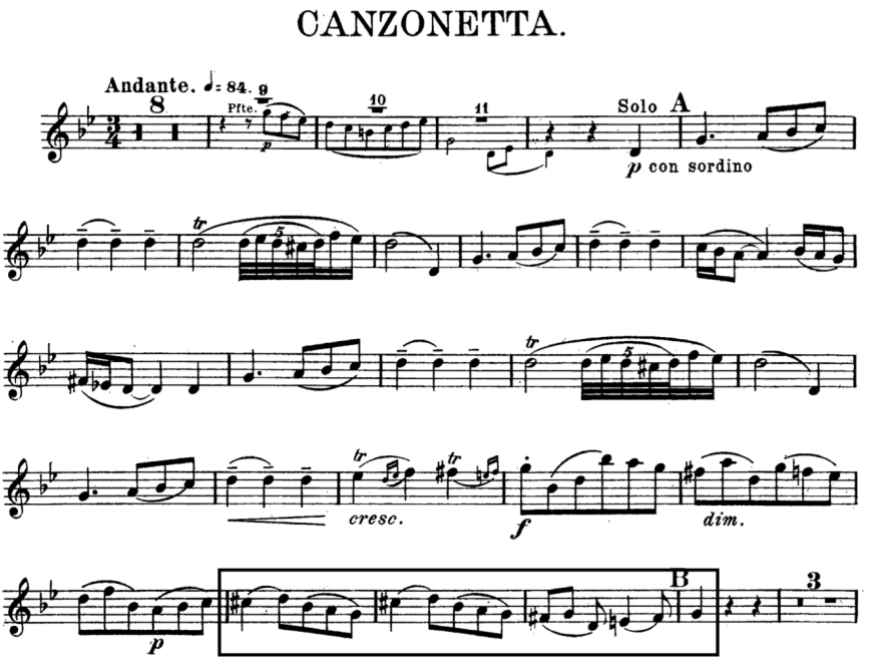
Bruch – Violin concerto no.1 in g minor, op. 26, from 1st movement (bar 6)



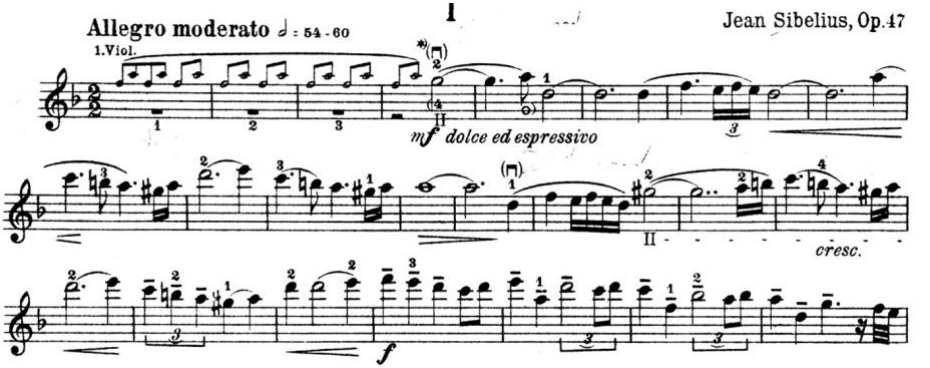
Brahms – Violin concerto in D major, op. 77, from 1st movement (bars 206-209)



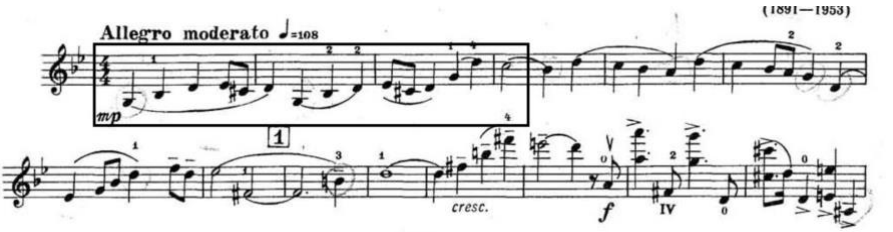
Tchaikovsky – Violin concerto in D major op. 35, from 2nd movement (bars 31-34)



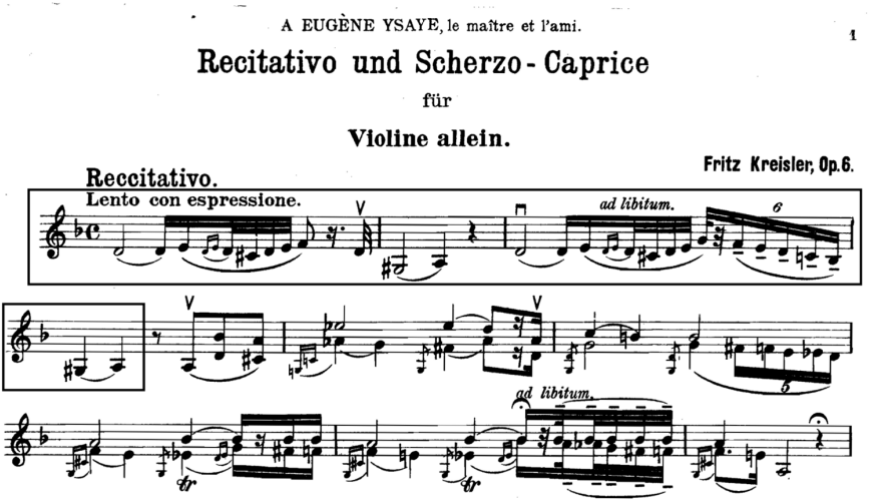
Sibelius – Violin concerto in d minor, op. 47, from 1st movement (bars 14-18)



Prokofiev – Violin concerto no.2 in g minor, op. 63, from 1st movement (bars 1-3)



Kreisler – Recitativo and Scherzo (bars 1-4), d minor



Appendix C: Listening order of excerpts and intonation variants (Study II)

Overview of the listening order (Versions A, B, C, and D), as applied to Participants 1–6 during the listening study.

A		B		C		D	
Part. 1 & 5		Part. 2 & 6		Part. 3		Part. 4	
Exc. No.	1st heard int.var. (cent)	Exc. No.	1st heard int.var. (cent)	Exc. No.	1st heard int.var. (cent)	Exc. No.	1st heard int.var. (cent)
5	130	4	50	5	50	4	130
6	130	3	130	6	50	3	50
7	50	2	50	7	130	2	130
8	130	1	50	8	50	1	130
1	50	8	130	1	130	8	50
2	50	7	50	2	130	7	130
3	130	6	130	3	50	6	50
4	50	5	130	4	130	5	50

Appendix D: Interview guide (Study II)

På svenska:

1. Hur upplevde du lyssningsstudien?
   1.1 Var det något/några utdrag som du vill särskilt lyfta fram?
   1.2 Kan du använda ett (eller två) ord för att beskriva den känslan du fick när du hörde den ”bästa” intonationen i det utdraget.
2. Vad är din syn på intonation och musikaliska uttryck i fiolspel? (Det finns inget rätt eller fel svar!)
3. Vad skulle vara dina bästa råd till fiolstudenter som vill bli bättre på intonation?

In English:

1. How did you experience the listening study?
   1.1 Was/Were there any excerpt(s) that you want to particularly mention?
   1.2 Please use one or two words to describe the feeling/emotion you got when hearing the “best” intonation variant in that excerpt.
2. What is your view of intonation and musical expressions in violin performance? (There are no right or wrong answers here!)
3. What would be your advice to violin students who want to improve their intonation?

KMH

Stråkdagarna 2022 – Enkät om intonation

Genom att signera detta formulär ger jag mitt samtycke till att mina svar får användas som forskningsmaterial av doktorand Sheng-Ying Isabella Weng och prof. Erkki Huovinen i deras forskning. Insamlat material kommer att anonymiseras och inga deltagare kommer att kunna identifieras i analysen. Uppgift om namn lämnas endast i syfte att vid behov kontrollera uppgifter.

1a Vad är det mest utmanande med intonation i din undervisning?

_____

_____

1b Hur har du försökt lösa det? Kan du beskriva ett konkret exempel från en undervisningssituation?

_____

_____

_____

_____

2a Vad tycker du är mest utmanande med intonation i ditt eget musicerande?

_____

_____

2b Hur tacklar du då den här utmaningen?

_____

_____

_____

_____

Signatur: _____

Namnförtydligande (bara för forskares kännedom): _____

Ålder: _____ Kön: _____ Huvudinstrument: _____

Hur många år har du aktivt spelat ditt huvudinstrument? _____

Vilka musikutbildningar har du?

☐ musik-/kulturskola
☐ folkhögskola med musikinriktning
☐ folkuniversitetet
☐ estetiskt program på gymnasiet
☐ studieförbund
☐ privatundervisning
☐ kandidatutbildning i musik, inriktning: _____
☐ masterutbildning i musik, inriktning: _____
☐ musiklärarutbildning, inriktning: _____
☐ doktorandutbildning i musik, inriktning: _____
☐ någon annan musikutbildning (specificera) _____

Hur länge har du arbetat som stråkpedagog? _____

Var undervisar du för tillfället?

☐ kulturskola
☐ folkhögskola med musikinriktning
☐ folkuniversitetet
☐ musikhögskola
☐ estetiskt program på gymnasiet
☐ studieförbund
☐ privatundervisning
☐ någon annan musikverksamhet (specificera) _____

Ange åldersspannet för majoriteten av dina elever: _____ till _____

Vilka genrer undervisar du i? ☐ klassisk ☐ folkmusik ☐ jazz ☐ populärmusik
☐ något annat, vad? _____

Har du någon favoritmusiker på ditt eget instrument? Om ja, vem? _____

Vad är det hos den här musikern som du uppskattar så mycket?

_____

_____

Om du är intresserad av att ta del av den här studiens resultat, kan du lämna din e-postadress här: _____

Tack för ditt bidrag!

Included publications

Article I: Expressive semitones: Music students' perceptual preferences for melodic intonation on the violin

Article II: Concertmasters' leading-tone intonation: Do they perform as they assess?

Article III: String teachers on the challenges of intonation: A report from Sweden

Article IV: Intonation and expressivity: Observations on string musicians' views as communicated in The Strad