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MENTAL TRAINING IN THE IMPROVEMENT OF VIOLIN PLAYING SKILL IN THE PRIMARY SCHOOL PEDAGOGICAL PROCESS

DOCTORAL THESIS

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Supervisor:
Professor Dr. paed. Māra Marnauza

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ABSTRACT

Fiona Vilnite's doctoral dissertation in music pedagogy *Mental Training in the Improvement of Violin Playing Skill in the Primary School Pedagogical Process* was developed at the Riga Teacher Training and Educational Management Academy, Faculty of Pedagogy between 2014 to 2017 and between 2018 and 2023 at the University of Latvia under the guidance of professor Dr. paed. Mara Marnauza.

The object of the research: the pedagogical process of violin playing in a specialist music primary school. The subject: students' violin playing skill. The goal: To investigate the essence of mental training, opportunities for its use in the improvement of violin playing skill and, as a result, develop a model for improving violin playing skill with students in a specialist music primary school and empirically test its effectiveness.

According to the goals of the research, the following theoretical methods were employed: analysis of scientific literature in pedagogy, music pedagogy and cognitive neuroscience; modelling of the pedagogical process. Empirical methods: Observation of individual lessons, concerts, exams and the creation of pedagogical situations; semi-structured interviews with expert violin pedagogues; computerised analysis of recordings, for studying intonation: *Celemony Melodyne Editor 4* software; computerised assessment of recordings, for studying dynamics: *Audacity 2.1.1.0* software; computerised assessment of pulse and rhythm using *Celemony Melodyne Editor 4*, statistical analysis using *IBM SPSS 21* and *Google Sheets*: Descriptive statistics (range, interquartile range); Wilcoxon Signed-Ranks Test; Kruskal-Wallis Test; Paired-Samples T-Test to analyse the dynamic range of the students' playing before and after using mental training. The basis of the research: A specialist music primary school; 8 violin teachers from Latvia and other countries.

The work analyses theories of mental training, its foundations in mental imagery, and its connections to the cognitive processes of learning. It adapts these aspects to provide an interdisciplinary approach to teaching and learning with the goal of developing student violin playing skill, whilst fostering student well-being. A mental training system was developed during the research process that alternates mental and physical practice, mental imagery, metaphors, creative experimentation, to aid in the development of student self-actualization of violin playing technique and musical skill. The system was introduced into one-to-one violin lessons of 9 violin students throughout two academic years, during which measurements and pedagogical observations took place, as well as corrections to the mental training system. The practical significance of this work includes the positive impact of mental training on the development of violin playing skill and offers a model for improvement of violin playing skill, a mental training system and an approach that can be integrated into routine violin lessons.

The results of the research confirm that the improvement of violin playing skill is more successful when students are interested in learning the violin through an individualised learning process, the violin teaching and learning process is founded upon the violin skill improvement model and integrated mental training system, and pedagogues purposefully incorporate the mental training system into individual violin lessons.

Keywords: mental training, violin playing, violin teaching, violin learning

ANOTĀCIJA

Fionas Mērijas Vilnītes (Fiona Mary Vilnite) promocijas darbs izglītības zinātnē, nozaru (mūzikas) pedagoģijas apakšnozarē "Mentālā vingrināšanās vijoļspēles prasmes pilnveidei pamatskolas pedagoģiskajā procesā izstrādāts Rīgas Pedagoģijas un izglītības vadības akadēmijā, Pedagoģijas fakultātē laika posmā no 2014. līdz 2017. gadam un Latvijas Universitātes Pedagoģijas, psiholoģijas un mākslas fakultātē no 2018. līdz 2023. gadam profesores *Dr. paed.* Māras Marnauzas vadībā.

Pētījuma objekts: Vijoļspēles pedagoģiskais process mūzikas novirziena pamatskolā. Pētījuma priekšmets: Skolēnu vijoļspēles prasme. Pētījuma mērķis: Izpētīt mentālās vingrināšanās būtību, tās pielietošanas iespējas vijoļspēles prasmes pilnveidei, kā rezultātā izstrādāt vijoļspēles prasmes pilnveides modeli mūzikas novirziena pamatskolas skolēniem un empīriski pārbaudīt tā efektivitāti.

Atbilstoši pētījuma mērķiem tika izmantotas šādas teorētiskās metodes: zinātniskās literatūras analīze pedagoģijā, psiholoģijā, mūzikas pedagoģijā un neirozinātnēs; pedagoģiskā procesa modelēšana. Empīriskās metodes: Individuālo nodarbību, koncertu, eksāmenu novērošana un pedagoģisko situāciju veidošana, daļēji strukturētas ekspertu – vijoļspēles pedagogu intervijas ar speciālistiem; Ierakstu datoranalīze, pētot intonāciju: programmatūra *Celemony Melodyne Editor 4*, Datorizēts ierakstu izvērtējums, pētot dinamiku: programmatūra *Audacity 2.1.1.0*, lai analizētu studentu vijoļspēles dinamikas diapazonu pirms un pēc tam, kad veikta mentālā vingrināšanās, datorizēts metra un ritma ierakstu izvērtējums, izmantojot programmatūru *Celemony Melodyne Editor 4,* Datu statistiskā analīze, kas iegūta ar ierakstu datorizētās analīzes starpniecību, izmantojot *IBM SPSS 21* un *Google Sheets*: aprakstošā statistika (diapazons, starpkvartiļu diapazons); Vilkoksona tests (*Wilcoxon Signed-Ranks Test*); Kruskala-Volisa tests (*Kruskall-Wallis Test*); Pāru paraugu t-tests (*Paired-Samples T-test*); Šapiro-Vilka tests *(Shapiro-Wilk test*). Pētījuma bāze: Mūzikas novirziena pamatskolas 2.–7. klases 9 vijoļspēles skolēni; 8 Latvijas un citu valstu vijoļspēles skolotāji.

Darbā tiek analizētas mentālās vingrināšanās teorijas, tās pamati mentālajā iztēlē un saikne ar mācīšanās kognitīvajiem procesiem. Pētījumā šie aspekti adaptēti, lai nodrošinātu starpdisciplināru pieeju pedagoģiskajām procesam ar mērķi attīstīt skolēnu vijoļspēles prasmi, vienlaikus veicinot skolēnu labbūtību. Pētījuma gaitā izstrādāta mentālās vingrināšanās sistēma, kas paredz pārmaiņus pielietot mentālos un fiziskos vingrinājumus, mentālo iztēli, metaforas, radošus eksperimentus, lai sekmētu skolēna instrumentspēles tehnikas un muzikālās izteiksmības pašizpausmi vijoļspēlē. Sistēma tika ieviesta deviņu vijoļspēles skolēnu individuālās mācību nodarbībās divu akadēmisko gadu garumā. Šai laikā tika veikti mērījumi un pedagoģiskie novērojumi, kā arī izdarītas mentālās vingrināšanās sistēmas korekcijas. Pētījuma praktiskā nozīmība ietver mentālās vingrināšanās pozitīvo ietekmi uz vijoļspēles prasmes attīstību, pētījumā piedāvāts vijoļspēles prasmes pilnveides modelis, mentālās vingrināšanās sistēma un pieeja, ko iespējams integrēt jebkurās vijoļspēles nodarbībās.

Pētījuma rezultāti apstiprina, ka vijoļspēles prasmes pilnveide ir sekmīgāka tajos gadījumos, kad skolēni ir ieinteresēti apgūt vijoļspēli individualizētā mācību procesā; vijoļspēles mācīšanas un mācīšanās process balstās uz vijoļspēles prasmes pilnveides modeli un integrētu mentālās vingrināšanās sistēmu; pedagogi mērķtiecīgi iekļauj mentālās vingrināšanās sistēmu individuālajās vijoļspēles nodarbībās.

Atslēgvārdi: mentālā vingrināšanās, vijoļspēles prasme, vijoļspēles pedagoģiskais process

CONTENTS

INTRODUCTION

The primary school pedagogical process significantly influences the formation of lifelong attitudes towards learning. Within this setting, music education assumes a vital role and learning a musical instrument has the potential to develop creativity, collaboration, cognitive and physical skill. The research in this doctoral dissertation was conducted at a specialist music primary school in Latvia, incorporating a professionally oriented curriculum with in-depth music learning. The results and requirements attainable in such a school differ from those of a children's music school. A children's music school, in contrast to a specialist music primary school, follows programmes with a professional focus, and upon completing the children's music school, studies can be continued at a music "middle school." However, graduates of a specialist music primary school need to pass an entrance examination to pursue further education at a music "middle school." The research offers a unique insight into the potential of individualised one-to-one instrumental learning processes, exploring how an approach that systematically integrates cognitive and physical skill can be introduced into pedagogical processes.

Discoveries in neuroscience have revealed how learning and experience change the brain (van Duijvenvoorde, et al., 2022; Sampaio-Baptista & Johansen-Berg, 2017; Zatorre et al., 2012). An increasing amount of research is linking discoveries in neuroscience to educational theory and practice (Hawkins, 2021; Wolfe, 2010; Willis, 2006), leading to the emergence of interdisciplinary fields such as Educational Neuroscience and Neuroeducation (Pykett, 2015; Peters, 2011). In addition to already existing and empirically tested research in pedagogy, these interdisciplinary fields are assisting in identifying conditions that facilitate or hinder learning and assist in understanding why methods or approaches succeed in some situations, whilst falter in others. Indeed, research in neuroscience has assisted in revealing how a significant proportion of adult learners have cumulative educational trauma (Gray, 2019), which can manifest as fear conditioning (Perry, 2006). These issues not only pose challenges on an individual level, but also have broader societal implications. Students who dissociate psychologically from the learning process may develop a reluctance to attend classes, leading to under-education, unemployment, and the perpetuation of intergenerational poverty (Carcillo et al., 2017). Conversely, individuals who continue in education often experience improved well-being (Guardiola & Guillen-Royo, 2015), enhanced job prospects, and increased socio-economic circumstances, creating an environment conducive to improved child learning (Vanderauwera et al., 2019). It is necessary to identify, therefore, the factors that encourage sustained interest in learning from its outset; factors that could contribute to the well-being of the individual and so then to society as a whole.

Music education in particular has been identified as being beneficial at both the individual and societal levels. Children who engage in music learning not only demonstrate enhanced proficiency in various domains, such as reading (Ozernov-Palchik & Patel, 2018), but also benefit from collaborative music education programs, such as the Suzuki method and El Sistema-inspired orchestral programs, which have successfully encouraged collaboration within and between communities, offering potential solutions to poverty-related challenges (Bolden et al., 2021; Wakin, 2012; Vulliamy, 2010). Despite the positive effects of such programmes however, approaches to music education, even the more modern ones, have been subject to criticism for their authoritarian, competitive, hyper-disciplined, and exploitative nature (Baker, 2014a & Baker, 2014b), thereby diminishing the personal and social aspects of learning to play a musical instrument. Therefore, an approach that is based deliberately and openly on scientific research in pedagogy and now also neuroscience, is necessary to identify problematic areas, increase awareness of the processes that facilitate or hinder learning, and replace "traditional," authoritative models prevalent in music education.

Indeed, it is possible to identify a disparity between pedagogical theories, findings in neuroscience, and the practical application of their concepts. These discrepancies are particularly evident in the field of music pedagogy (Hodges & Gruhn, 2019; Flohr, 2010), where current practices often lack consideration for integrative theories of the brain, cognition, and even pedagogy itself. Additionally, it would seem that insufficient attention is given to understanding the complex relationship between the internal and external environments that shape the teaching and learning process. Consequently, integrative approaches that could greatly benefit students may be underutilised, whilst other approaches may be emphasised without sufficient foundation. As a result, learning may be compromised, and the joy of learning and inquisitiveness amongst students may be lost, potentially leading to adverse effects such as educational trauma and fear conditioning identified in various studies (Gray, 2019; Perry, 2006).

Evidence supporting these concerns can be observed when considering the growing number of professional orchestral musicians who resort to medication (Beder, 2016; Breda & Kulesa, 1999; Fishbein, 1987) or struggle with addiction (Saintilan, 2020; Cannell et al., 2014) and stress-related issues that exacerbate or trigger physical injuries (Ioannaou, et al., 2016). Whilst these could be assigned to issues of dealing with stage fright, these challenges may also indicate gaps in the basic educational processes of learning an instrument, prompting the question of why musicians encounter difficulties in applying a skill they have developed over decades.

Drawing upon personal experiences as a professional violinist, preparing for concerts and recordings and working as a violin teacher in both the United Kingdom and Latvia, revealed that the techniques of mental training, essential for achieving high musical and artistic standards, were frequently omitted in standard instrumental education, even though successful playing and performance directly depends on the strength of the relationship between mental and physical aspects. It also revealed that the connections between mental concepts of sound, movement, musical understanding, interpretation, and their physical realisation on the instrument were indeed already relevant during the learning processes of young violinists. However, there is currently a lack of methodological literature for violin teachers addressing the training of these connections together with young violinists, as well as recommendations for integrating such training into pedagogical approaches. This dearth of literature can be witnessed not only in the literature in Latvian, but also in English language publications. Whilst literature on mental training exists in English and German, it is derived predominantly from the field of professional sport and from sport psychology. Similarly, existing publications connected to mental training in music cater for already-trained practitioners (e. g. Cornett, 2019; Green & Gallwey 2015; Klöppel, 2010). The integration of mental training approaches into novice learning environments remains unexplored. The existing literature on mental training lacks comprehensive explanations regarding the neural processes involved during its utilisation and their connections to the learning processes within the brain. Establishing these links would be essential in facilitating the integration of mental training into novice learning environments. It is perhaps unsurprising, therefore, that no literature presently exists, either in the field of violin playing or violin pedagogy, that is specifically dedicated to addressing the issues of mental training for violinists.

The problems above have established the choice and relevance of the theme of this doctoral thesis: **Mental Training in the Improvement of Violin Playing Skill in the Primary School Pedagogical Process**.

Research Object: The pedagogical process of violin playing in a specialist music primary school.

Research Subject: Students' violin playing skill.

Research Goal: To investigate the essence of mental training, opportunities for its use in the improvement of violin playing skill and, as a result, develop a model for improving violin playing skill with students in a specialist music primary school and empirically test its effectiveness.

Hypothesis

The improvement of violin playing skill in the specialist music primary school pedagogical process will be more successful if:

- students are interested in learning the violin in an individualised learning process;
- the violin teaching and learning process is based on the violin skill improvement model;
- teachers use the mental training system purposefully in individual violin lessons.

Research Objectives

1) To research the theoretical basis of mental training in the psychology, neuroscience and pedagogy literature.
2) To analyse the theoretical foundations and practice of learning the violin in the specialist music primary school pedagogical process.

3) To develop a model for the improvement of violin playing skill, which includes mental training tasks, and to empirically test its effectiveness.

Research Methods

Theoretical methods

- Analysis of the scientific literature in pedagogy, psychology, neuroscience, violin playing pedagogy and mental training.
- Modelling of the pedagogical process.

Empirical methods

- Observation of individual lessons, concerts, exams and the creation of pedagogical situations.
- Semi-structured interviews with experts.
- Computerised analysis of recordings, for studying intonation: *Celemony Melodyne Editor 4* software.
- Computerised assessment of recordings, for studying dynamics: *Audacity 2.1.1.0* software, to analyse the dynamic range of the students' playing before and after using mental training.
- Computerised assessment of pulse and rhythm using *Celemony Melodyne Editor 4*.
- Statistical analysis using IBM SPSS 21 and Google Sheets: Descriptive statistics (range, interquartile range); Wilcoxon Signed-Ranks Test; Kruskal-Wallis Test; Paired-Samples T-Test.

Basis and Location of the Research

A specialist music primary school: 9 violin students from classes 2 to 7; 8 violin teachers from Latvia and other countries.

Research Stages

2014–2015	Development of theoretical concept; preparation of the research process.
2015–2016	Development of the thesis' empirical concept; the beginning of the empirical research.
2016–2017	Organisation of theoretical chapters and statistical analysis of empirical results.
2017–2019	Formulation of dissertation.
2019–2022	Formulation and completion of dissertation and approbation of the research.
2022–2023	Updating of the theoretical chapters with the latest scientific sources and supplementation of the empirical research through partially structured interviews with expert violin pedagogues with the goal of substantiating the usefulness and application of the developed "System of Mental Training for the Improvement of the Skill of Violin Playing" in the process of violin teaching and learning.

Theoretical Basis of the Research

Humanistic pedagogy in approach to the pedagogical process: C. Rogers (1969) concepts of the person-centred approach and expanded hierarchy of needs; A. Maslow (1943) hierarchy of needs; A. Bandura (1995) self-efficacy theory; J. Dewey (1909) thought processes.

Activity theory and personality theories: A. N. Ļeontiev (1977); Vygotsky (1930, 1978) use of thought processes, psychological tools, mediators in activity, zone of proximal development and its relevance to mental training; A. Kozulin et al. (2003) cultural context of activity theory in connection to diversity of thought and creativity in the pedagogical process; A. Luria (1968) personal relevance in learning and memory recall in connection to creation of personally relevant mental imagery.

Experiential Learning Theory: D. Kolb (1984; 2012; 2018) student experimentation and similarities between experiential learning and mental training in the pedagogical process.

Individual approach: C. Rogers (1961) approach to the teaching and learning process; J. S Bruner (1964) construction of student's own world, relationship of inner and outer processes; P. Barker, P. van Schaik (2011) mental models and lifelong learning.

Mental training and mental imagery theories: J. Mayer, H. D. Hermann (2011) definitions and scope of mental training; N. J. T. Thomas (2016) mental imagery definitions and connections to creativity; A. Moran, H. O'Shea (2020), A. J. Toth, E. McNeill, K. Hayes, A. P. Moran, M. Campbell (2020); Floridou et al. (2022) mental imagery as a cognitive tool in mental training; T. Morris, M. Spittle, A. Watt (2005) effects of mental imagery on performance; B. Nanay (2018) multimodal mental imagery; K. N. Cotter (2019) the specificities of musical imagery; R. Klöppel (2010) use of mental training in music; W. T. Gallwey (1974), B. Green, W. T. Gallwey (2015) use of the "inner game" in sport and music: similarities to mental training; C. R. Hirsch, A. Mathews, D. M. Clark, R. Williams, J. A. Morrison (2006) negative mental imagery and anxiety; G. Lotfi, F. Tahmasbi, M. H. Forghani, A. Szwarc (2020) effects of positive and negative imagery on skill learning; M. Stergiou, K. Raheb, Y Ioannidis (2019) metaphoric imagery and sensory-motor concepts; B. DeSantis, S. Deck, C. Hall, S. Roland (2022) illustration of concepts and knowledge through mental imagery; B. Nanay (2021) unconscious mental imagery and aphantasia.

Mental processes of music performance and learning in neuroscience: G. Ganis, A. Thompson, S. M. Kosslyn (2004) activation of brain areas during actual perception and mental perception; R. J. Zatorre, A. R. Halpern (2005), S. E. Bastepe-Gray, N. Acer, K. Z. Gumus, J. F Gray, L. Degirmencioglu (2020) activation of auditory areas in actual and imagined sound; S. Kosslyn, C. Seger, J. R. Pani, L. A. Hilliger (1990) spontaneous use of mental imagery; J. Haueisen, T. R. Knösche (2001) motor region activation during observation; B Haslinger, P. Erhard, E. Altenmüller, U. Schroeder, H. Boecker, A.O. Ceballos-Baumann (2005) auditory area activation during silent observation of performance; Pascuale-Leone (1995) evidence of neuroplasticity in learning and mental training; S. Sugio, K. Daisuke,

H. Wake, (2022) neuroplasticity and skill learning; S. Hishitani (2011) neural effects of negative mental imagery; Linde-Domingo (2019) use of mental imagery in memory retrieval.

Educational neuroscience: J. Willis (2006) multimodal learning; P. Wolfe (2010); B. Perry (2006) effects of stress on immediate and lifelong learning; A. Amaral (2021) neuroplasticity and connections between networks of neurons in learning.

Developmental theories: J. Piaget (1973) mental imagery in developmental stages; L. Vygotsky (1978) the "Zone of Proximal Development"; A. Bandura (1977) modelling and the "Social Learning theory."

Mental training in the primary school age group: T. Orlick, N. McCaffrey (1991) approaches and adaptations of mental training components for children; S. E. Short, J. Afremow, L. Overby (2001) adaptation of imagery techniques for children.

Mental training components in music pedagogy: Haddon (2005) lack of conscious mental imagery use in pedagogical process; G. E. McPherson (2005) mental strategies used in the beginning stages of learning a musical instrument.

Violin pedagogy: S. Fischer (1997; 2013) technical components of violin playing; I. Galamian (1962) correlation of mental and physical skills; D. M. Dounis (1921, 1925, 1935) mental aspects in learning violin technique; G. Eberhardt (1910) exercises to develop mental control in violin technique.

Research Novelty

- Conceptualises the use of mental training purposefully and specifically for the acquisition of violin playing skills in the violin teaching and learning process.
- Formulation of assessment criteria and indicators of the components of violin playing.
- Formulation of a violin skill improvement model.
- Provides a structure and practical approach to teaching and learning that integrates theories from neuroscience, psychology and pedagogy.

Practical Meaning of the Research

- A developed and empirically tested mental training system for improving violin playing skill in the process of teaching and learning the violin
- The realisation and usefulness of these exercises in the individual violin lessons of students at a specialist music primary school
- A mental training system for violin teachers for use in the pedagogical process of young violinists

Approbation of the Research Results

Participation in Scientific Conferences with Presentations

1) Research in Music Education: The 13th International Conference. 11–14 April 2023. Paper presentation: "Thinking Ahead: The Use of Mental Training in Young Violinists' Skill Development," London, England. Conference held online.

2) Association for Teacher Education in Europe (ATEE) Annual Conference "To Be, or Not to Be a Great Educator." Paper presentation: "Mental training in developing skill, musical interpretation and performance in young violinists." University of Latvia 29–31.09.2022
3) 11th International Scientific Conference "Problems in Music Pedagogy." Paper presentation: "The Use of Mental Training in the Development of Rhythm and Intonation in the Primary School Violin Teaching and Learning Process." Daugavpils Universitāte 26.–27.09.2019
4) 20. Starptautiskā zinātniskā konference "Sabiedrība un kultūra," Liepāja University. Paper presentation: "The Use of Mental Imagery and its Effects On Dynamic Contrast in Primary School Violin Students' Musical Interpretations." Liepāja University, 19.–20.05.2017.
5) RPIVA XII Starptautiskā Jauno zinātnieku conference. Essay: "Developing Violin Playing Skills with Mental Training in the Primary School Violin Teaching and Learning Process." Riga Teacher Training and Educational Management Academy, Riga, 8.–9.12.2016.
6) 9th International Scientific Conference, *Theory and Practice in the Education of Contemporary Society*, Riga, Latvia. Essay: "The Age-Related Specificities of Using Mental Training in the Primary School Violin Teaching and Learning Process". Riga Teacher Training and Educational Management Academy, Riga, 14–15.04.2016
7) 24th European Association for Music in Schools Conference *Looking for the Unexpected: Creativity and Innovation in Music Education*. Referāts: "Opportunities for Procedural Incorporation of Mental Training in the Violin Teaching and Learning Process of Students in the Primary School Age Group". Lithuanian Academy of Music and Theatre, Vilnius, Lithuania, 16.–19.03.2016.
8) RPIVA XI Starptautiskā Jauno zinātnieku konference. Referāts: "Pamatskolas vecuma skolēnu vijoļspēles prasmju komponenti un to vērtēšanas kritēriju analīze". RPIVA, 3.–4.12.2015
9) Daugavpils Universitātes 9. Starptautiskajā zinātniskajā konferencē *Problēmas mūzikas pedagoģijā*. Referāts: "Mental Training and its Use in String Pedagogy." Daugavpils Universitāte 25.–26.09.2015
10) Rēzeknes Augstskolas IV starptautiskā zinātniski praktiskā conference *Māksla un mūzika kultūras diskursā*. Referāts: "The Essence of Mental Training and Opportunities for its Use in the Violin Teaching and Learning Process of Students in Primary School Education." Rēzeknes Augstskolā, 24.–25.09.2105
11) Jāzepa Vītola Latvijas Mūzikas akadēmijas conference *Mūzikas Pētījumi Latvijā*. Referāts: "Mentālā vingrināšanās un tās komponentu apzināšana vijoļspēles metodikas vesture." JVLMA, 26.–27.03.2015
12) RPIVA X Starptautiskā Jauno zinātnieku konference. Referāts: "Vijoļspēles komponenti un mentālais attēlojums sākumskolas skolēnu vijoļspēles mācību procesā." RPIVA, 28.–29.11.2014
13) Nordic Network for Music Education (NNME): *Quality in music teaching, learning and knowledge – perspectives on assessment and evaluation*. Referāts: "The Role of Mental

Training in the Teaching and Learning Process of Primary School Violin Students". Estonian Academy of Music, Tallin, Estonia, 3.–7.11.2014.

Publications

1) Vilnite, F. M., Marnauza, M. (2023). Thinking Ahead: The Use of Mental Training in Young Violinists' Skill Development. *Music Education Research*, (Routledge), Vol. 25, No. 5, (p. 545–561), DOI: 10.1080/14613808.2023.2272166. https://doi.org/10.1080/14613808.2023.2272166 *Open access.* Indexed in:
2) Abstracts of Music Literature; Academic Search; Australian Education Index; Australian Research Council (ARC) Ranked Journal List; British Education Index; Educational Research Abstracts online (ERA); **RILM**; **EBSCOhost** EJS; Education Resources Information Center (**ERIC**); **ERIH** (European Reference Index for the Humanities, Pedagogical and Educational Research); National Database for Research into International Education; IBR (International Bibliography of Book Reviews of Scholarly Literature on the Humanities and Social Sciences); The Music Index: A Subject-Author Guide to Music Periodical Literature; **SCOPUS**®; **Web of Science:** Social Sciences Citation Index® and the Arts and Humanities Citation Index®
3) Vilnite, F. M., Marnauza, M. (2019). The Use of Mental Training in the Development of Rhythm and Intonation in the Primary School Violin Teaching and Learning Process. Problems in Music Pedagogy, Vol. 18(1), 2019, (pp. 57–73). Daugavpils: Daugavpils Universitāte. ISSN 1691-2721 EBSCO, ERIH PLUS, ProQuest
4) Vilnite, F. M. (2017). The Use of Mental Imagery and Its Effects on Dynamic Contrast in Primary School Violin Students' Musical Interpretations. 20. starptautiskās zinātniskās konferences "Sabiedrība un kultūra: Izziņa un jaunas zināšanas rakstu krājums". Liepāja: Liepājas Universitāte. ISSN 14076918
5) Vilnite, F. M., Marnauza, M. (2015). The Essence of Mental Training and Opportunities for its Use in the Violin Teaching and Learning Process of Students in Primary School Education. IV starptautiskās zinātniski praktiskās konferences "Māksla un Mūzika Māksla un mūzika kultūras diskursā" rakstu krājums. Rēzekne: Rēzeknes Augstskola. ISBN 978-9984-44-183-2, ISSN 2256-022X.
6) Vilnite, F. M., Marnauza, M. (2015). Mental Training and Its Use in String Pedagogy. Problems in Music Pedagogy, Vol. 14(2), 2015 (pp. 145–159). Daugavpils: Daugavpils Universitāte. ISSN 1691-2721. EBSCO, ERIH PLUS, ProQuest.

1. THE THEORETICAL BASIS OF MENTAL TRAINING AS A PEDAGOGICAL TOOL IN THE ACQUIREMENT OF PRIMARY SCHOOL STUDENT VIOLIN PLAYING SKILL

1.1. The Understanding of Mental Processes and the Basis of Mental Training

Current research in neuroscience is helping to reveal an understanding of mental processes: that both thought and activity change brain structure and function (Doidge, 2007; 2015). This change, referred to as *neuroplasticity*, has been identified as being central to learning (Joshua, 2022; Willis, 2006).

Developed separately from neuroscience and used by already-trained practitioners in sports and music, mental training directly brings into awareness the relationship between inner and outer processes, often realised through alternating mental and physical practice (see Kloppel, 2010). Yet, for decades the reasons for its positive effects on learning and performance were not entirely understood. However, studies in neuroscience have taken aspects of mental training such as mental practice, and concluded they also promote neuroplasticity in the brain (Avanzino et al., 2015); that the components of mental training assist in the learning process. One landmark study in neuroscience revealed that skill improvement in learning a musical instrument using mental practice is not limited to already-trained practitioners but is apparent also in novices; that after mental practice novices also showed a propensity for further learning (Pascuale-Leone, 1995). This was also echoed by a study that compared mental practice research between 1995 and 2018, and which revealed statistically significant skill improvement in novices (Toth et al., 2020) and a study that noted that alternating physical and mental practice in novices developed more similar skill attributes to professionals, compared to novices who practised purely physically (Frank et al., 2016).

These observations prompt pertinent questions. Considering their benefits in learning, why are aspects of mental training rarely used systematically in the pedagogical process of learning a musical instrument? Whilst there may not be a definitive answer, one possible explanation may be connected to non-uniformity of labelling (Haddon, 2007), meaning that even if aspects of mental training are employed, they may not be identified as such. Thus, they may become obscured amongst various pedagogical approaches, leading to unintentional use and diminished effectiveness.

Additionally, whilst components of mental training have provided a framework for researching the mental processes connected to learning in neuroscience, there is currently a dearth of literature concerning mental training that is inspired by the insights from both neuroscience and from pedagogy itself. This current lack of interdisciplinary dynamicism in mental training not only limits its further development with already-trained practitioners, but also prevents its conscious and deliberate expansion into pedagogical processes. This should not be the case, however, since the processes explored in mental training are similar to those identified as being at the basis of learning in neuroscience.

It is perhaps unsurprising, therefore, that there is no current literature that discusses both the systematic inclusion of mental training in pedagogical processes and in the pedagogical process of young violinists.

By connecting the mental and neural processes involved in learning and mental training, this chapter aims to address the basis of these issues, outlining the homogeneity of mental training, learning, research and theories in psychology and pedagogy. These include humanistic education, theories of upbringing (Latvian: *audzināšana*), cognitivism, constructivism, activity theory, individualised approaches – and finally to the creative acquisition of skill in the field of music pedagogy.

Terms and Definitions

The term "**mental training**," from the German term *Mentales Training* has been defined in the context of sport as (1) the training of mental practice of action, without its accompanying movement (Eberspächer, 2007) and (2) used in sports psychology for developing awareness of the psychological and cognitive aspects which influence the learning and performance of a task (Mayer & Hermann, 2011).

The term in music has been used similarly, where the ultimate goal is not movement alone, but the sound that the movement creates (Klöppel, 2010). Based on the conscious manipulation of mental imagery – "seeing" in the mind's eye, which can be based on any sense mode, including visual, haptic/motoric, auditory, or any combination of those (Thomas, 2016) – the process of mental training used with already-trained practitioners frequently consists of a preparatory phase of progressive relaxation, followed by mental imagery of movements and/or sounds, followed by its practical realisation on the instrument (see Klöppel, 2010). Alternation of mental and physical practice is a major aspect in mental training, which also provides an opportunity for awareness of psychological and cognitive aspects of learning noted in sports psychology.

Whilst the term "mental training" is not frequently used in Anglo-American publications, the term has been used in music pedagogy in Paul Buyer's prequel and report of the Percussive Arts Society International Convention entitled "Mental Training in Percussion" (Buyer, 2008, 2009). P. Buyer outlines the scope of mental training to include the concepts from the German literature and references other terms frequently used in Anglo-American publications (see below).

These terms describe techniques which are related to mental training and included within the scope of the German definition and its use in sports psychology but may not include all of its components. Research including these terminologies will also be referenced in this dissertation.

"Mental Practice" – in Anglo-American literature, defined as: "The symbolic rehearsal of a physical activity in the absence of any gross muscular movements" (Richardson, 1967, 95). This component equates to definition (1) of the German term "Mentales Training." James E. Driskell et al., in their paper reviewing and comparing mental practice research, stated they regarded the term "mental practice" to describe a training technique whereby a "procedure required to perform a task is mentally rehearsed in the absence of actual physical movement" and they did not review other research that included any form of "cognitive or emotional" preparation strategy (Driskell et al., 1994, 481). Indeed, much of the literature that uses the term "mental practice" also excludes additional strategies.

"Mental Rehearsal" – (Anglo-American), This term equates to the first definition of the German term, with an influence of its use in sports psychology. John Annet, *in the Oxford Companion to the Mind* defines this term using the same definition that Alan Richardson gave for the term "Mental Practice" (Annet, 2004), but also notes the influence of the "Inner Game" – see below.

"The Inner Game" – A term coined by T. W. Gallwey in his book the "Inner Game of Tennis" (Gallwey, 1974), and later used and acknowledged by other sports psychologists, including Gary Mack (Mack, Casstevens, 2001) to refer to the mental processes and skills behind the "outer game" of performance. The concepts connected to this term correspond to both the first and second definitions of the term "mental training."

"Mental Imagery" – An essential foundational component of mental training, mental imagery is commonly defined as a quasi-perceptual experience that mirrors actual, perceptual experience, but however happens in the absence of external stimuli (Thomas, 2016). Colloquially referred to as "visualisation," mental imagery is widely employed in connection with the visual mode of imagination but can also be used in connection with any sense mode: auditory, kinaesthetic/motor, olfactory, haptic or any combination of them. Authors have identified that a direct and deliberate application of mental imagery is mental practice (Toth et al., 2020; Moran, O'Shea, 2020) and that mental imagery is a cognitive tool in mental training (Floridou et al., 2022). Indeed, the term "mental imagery" has long been used in the field of cognitive neuroscience in studying the nature of image formation in the mind (e.g. Pearson, 2019; Kosslyn, 1995).

"Internal and External Imagery." Sports psychologists have differentiated *internal imagery* – where the athlete imagines the internal feeling of, for example, kinaesthetic imagery – and *external imagery,* where an athlete employs an external view of himself performing (Mizuguchi et al., 2012; Kent, 2006). Paul Buyer outlines this as an important part of "mental training" in a musical context (Buyer, 2008) and is also used as a technique, though not labelled as such, by Renate Klöppel in a musical setting in her German language publication on mental training (Klöppel, 2010).

"Direct" and "Indirect" Mental Imagery. Authors have specified the difference between *direct* mental imagery – which is imagery used in the direct imagination of a task or skill, as used in mental practice, metal rehearsal, and which can involve internal and external imagery – and *indirect* or *metaphoric* mental imagery – which is imagery associated with a certain object or idea, perhaps even abstract, which can provide sensory-motor concepts relating to an action or skill (e. g. Stergiou et al., 2019; Pecher et al., 2011; Short et al., 2001;) or concepts of subjects and knowledge (e. g. DeSantis et al., 2022; Saban, 2008).

Interpretation and discussion of the terms

It is important to note that the techniques associated with the terms above were developed with already-trained practitioners, and although many of the definitions by default concern cognitive aspects, their precise connections to learning remain undiscussed in much of the mental training literature. Not only does this omission have the danger of impeding the development of mental training with current its proponents, but it is also a likely reason for its omission in pedagogical processes.

Whilst this situation can be understood, since it is only in the last few decades that neuroscience has assisted in revealing the processes of cognition in the brain, there is a clear divide in much of the mental training literature: texts that disregard components that can be identified as affecting cognition – including approach to and environment of practice and learning – and texts that effectively depend on them.

This divide in the mental training literature can be clearly seen in James E. Driskell et al's review and evaluation of the effectiveness of various academic studies involving *mental practice*, which distinctly disregards the effects noted in any study that employs so-called "disparate techniques" – those that "share a goal of enhancing performance, including positive imagery, psyching-up strategies, attention focusing, relaxation, self-efficacy statements, and other forms of cognitive or emotional preparation prior to performance" (Driskell et al., 1994, 481). These, they identify and perhaps correctly define, as "mental preparation," but their importance to cognition and the successful execution of mental and physical practice is not analysed.

On the other hand, there is literature that specifically examines the application of *mental imagery* in the practice routine, that has directly identified the link between these preparatory, cognitive, components in mental training to the success, or failure of its physical realisation. Sports author Tony Morris identified that positive mental images must be formed in the mind, otherwise repeated negative images, where the athlete breaks down at the "point of maximum effort," inhibit performance. "What we imagine can make us anxious or confident, determine our focus during play, motivate us to extra effort, or convince us that all is lost" (Morris et al., 2005, 5). Robert Woolfolk et al., also determined that positive imagery enhances abilities on a motor skill task – such as putting a golf ball – whilst negative imagery shows a deterioration of skill. Interestingly, their study also revealed that no imagery at all showed neither improvement nor deterioration of skill (Woolfolk et al., 1985). A more recent study in sport also confirmed that imagery that is positive showed a statistically significant improvement in skill compared to that of negative imagery (Lotfi et al., 2020).

When determining the scope of the term "mental training" it would seem therefore, that it is important to note that it is not purely the imagination, or the formation of a mental image *per se* that is an important factor, but also *how* the mental images are formed and *why* they become formed in certain ways: that the process of imagery formation influences cognition and learning. Interestingly, it is this aspect of mental training that shares similarities with the concept of intellectual and reflective thought discussed by John Dewey. He noted that thoughts are governed by beliefs – a type of mental hypothesis – for which the mind will seek confirmatory evidence (Dewey, 1909). In the context of instrumental teaching and learning, a belief by the student that a piece of music is difficult, for instance, could create a situation where the student is looking for evidence of this, which effectively creates an imperfect mental image of learning, playing and performing a musical work. This may then negatively influence practical realisation of playing, thus providing evidence for the original belief or hypothesis that the musical work is too difficult.

These combined observations illustrate the important relationship of two aspects of *mental training*: the psychological aspect, sometimes termed *mental preparation* – which includes the need for a neutral or positive psychological state that can help to provide a basis upon which to create positive mental images – and the creation of positive imagery itself, which not only envisages a practical task, but which then also creates more confidence and precision during its practical realisation.

Thus, the term "mental training" which incorporates the alternation of mental and physical practice together with cognitive and psychological factors that influence it – was chosen as the basis of the term "mental training" in this dissertation. However, research that uses the other terms listed above will also be referred to, since they describe aspects included within the scope of the term "mental training."

To understand how each separate component of mental training can be included in pedagogical processes, it is necessary to understand the mental processes connected to learning, and how this relates to the basis of mental training. This can then assist in the process of connecting its components to pedagogical theory and identify its potential application in the learning processes of playing the violin.

Mental image formation as a basis of mental training. Mental training could not occur without the use of mental imagery. The fact that mental practice involves manipulating mental imagery has been acknowledged by several authors in the field of sport (Morris et al., 2005; Amasiatu, 2013) and psychology (Moran & O'Shea, 2020). Far from being an abstract concept, research in the field of cognitive neuroscience has concluded that mental imagery is based in everyday thought processes (Kosslyn et al., 1990) that may or may not be consciously employed (Nanay, 2021). Its use has been noted in memory recall, for instance: thinking about how many windows there are in the living room, or (Kosslyn, 1995) and in story reading – visualising the characters and events in that story (McCrum 2016; Sadoski, 1985). As it is known that mental imagery is not confined to the *visual* sense mode, it is interesting to note that S. Kosslyn's survey of everyday mental imagery found that whilst visual mental imagery was the most commonly used, the experience of *auditory* imagery was actually more vivid than visual mental imagery, (Kosslyn et al., 1990). Examples of everyday auditory imagery could include thinking about whether one sound, such as a cat's meow, is higher or lower in pitch than the sound of a blender (Kosslyn, 1995).

The extent to which imagery is conscious or unconscious, and the level of awareness of its use, varies among individuals. For example, some people may be highly aware of the mental images they create and actively use them to guide their behaviour, while others may have less awareness of their imagery and use it more automatically, which may help to explain some occurrences of *aphantasia* – the inability to form mental imagery (Nanay, 2021). Indeed, auditory imagery has been found to be used both deliberately and involuntarily (Cotter et al., 2019). Research has shown that involuntary musical auditory imagery can be triggered by a variety of factors, such as hearing a piece of music which is then replayed in one's mind after the external stimulation has stopped (Liikkanen, 2008). Additionally, it can also be triggered by emotional states (Williamson & Jilka, 2014), and vivid representations of melody, lyrics, and musical timbre are common (Bailes, 2007). Deliberate or conscious employment of musical or auditory mental imagery has been noted as assisting musicians in attaining artistic goals in musical performance and composition, helping musicians to mentally rehearse, anticipate, and create music (Cotter et al., 2019).

This observation of the everyday conscious or unconscious employment of mental imagery as a key component of thinking and processing thought, can be connected to the observations noted in the field of psychology – and ultimately also pedagogy – about everyday thinking processes: that far from being static, these processes are also animated and are associated with future actions we may take. The following observations by Albert Bandura on the subject of self-efficacy illustrate this, plus reflect the observations in sport concerning the effect of negative and positive imagery: "Most courses of action are initially organised in thought. People's beliefs in their efficacy shape the types of anticipatory scenarios they construct and rehearse. Those who have a high sense of efficacy visualise success scenarios that provide positive guides and supports for performance. Those who doubt their efficacy visualise failure scenarios and dwell on the many things that can go wrong. It is difficult to achieve much while fighting self-doubt" (Bandura, 1995, 6).

So, it would seem that Albert Bandura's observations essentially support the concept that animated imagery – an important component in mental training – is also a part of everyday thinking processes. It is the conscious and deliberate manipulation of mental imagery that distinguishes mental practice and mental training from the everyday process of mental imagery, however. Its manipulation and awareness of the circumstances which influence its creation, forms an important part of mental training (Mayer & Hermann, 2011).

Interestingly, the fascination of controlling and manipulating a mental image had been noted in times of antiquity, where the anonymous author of the Latin book *Ad Herennium*, thought to be written in the 90s BC, encouraged students to develop their own imagery as an aid to memory (Yates, 1966). Closer to current times, Alexander Luria noted the use of mental imagery in one of his case studies by a subject who mentally imaged new information and placed these new images into other images of locations familiar to him. In doing so, he could memorise an enormous amount of information and retain the information over many years (Luria, 1968).

Modern research in neuroscience also substantiates these earlier observations – that imagery indeed plays an important role in memory retrieval and that the brain areas supporting imagery and memory retrieval overlap (Linde-Domingo et al., 2019; Huijbers et al., 2011). Additionally, the encouragement of students to develop personalised imagery connects to the modern literature in neuroeducation, where the role of mental imagery in learning has been discussed – that for learnt information to move from the short-term memory to the long term memory, several different points of association need to be established. Conscious employment of mental imagery, connecting matters to a subject which is personally significant assists in interacting with the subject content, which in turn helps to create stronger memory associations and therefore strengthen connections between neurons in the brain (Willis, 2006). Indeed, research in neuroscience has revealed that the wider the network of activated neurons – that is, the more varied the regions of brain activations that these networks cover – the stronger these networks and connections between the neurons in these networks become, the longer-lasting learning becomes (Amaral, 2021).

So it would seem that mental imagery, which is essential to mental training, is also central to everyday thought processes, memory recall and in helping to connect new information being learnt to personally relevant experience. But to understand exactly how manipulation of mental imagery, as carried out in mental training, facilitates the learning and memorisation of new information, and how components that encourage this could be included organically in pedagogical situations, it is necessary to look at how learning is described in the field of pedagogy and additionally what processes occur in the brain during learning.

Learning processes. Whilst there are many theories of learning in pedagogy, Dale H. Schunk proposes that learning in modern educational theory is predominantly represented by behavioural and cognitive learning theories. He notes that behavioural theories posit that learning is indicated by a change in behaviour – its rate, its regularity or its incidence – whilst cognitive theories hold that learning involves a change in mental processes that consequently result in behaviours (Schunk, 2014).

In neuroscience, the area of the brain that has been identified as registering new information is the prefrontal cortex. This has been regarded as the store for the short-term, or working, memory, and where information is registered before it can be sent to the long-term memory (Chini & Hanganu-Opatz, 2021; Pillay, 2011). The prefrontal cortex has links to other parts of the brain – including, the visual cortex for visual data processing, and Broca's area, for language processing. In the latter case, word sounds are repeated in the mind as a quasi-inner voice to keep them "in mind" (Mastin, 2010). Interestingly, Broca's area is responsible for connecting one's thoughts to language abilities and damage to this area impedes the translation of mental imagery to words (Acharya & Wroten, 2022). Auditory connections to the pre-frontal cortex have also been established, where processes of auditory detection and discrimination occur (Plakke & Romanski, 2014). Past research has indicated that the capacity of short-term memory in adults is limited to about five to nine items (Miller, 1956) and can last for about 15 to 30 seconds (Atkinson & Shiffrin, 1971). However, it has been noted that this time can be extended if: a) information is "chunked" – i.e. arranged into shorter, more "manageable" groups; b) if repetition or rehearsal occurs – either aloud or, significantly for this study: c) by mental simulation. When several components are held in the short-term memory, they effectively compete for recall, and newer information tends to push out the older, unless it is again rehearsed, or attention is brought to it in some way (Mastin, 2010). The same author notes the controversy about exactly how information moves from the short to the long-term memory. Indeed, one researcher has put forward a theory that there is no real distinction between the short- and long-term memories (Tarnow, 2009).

On a cellular level, learning can be detected in the brain through changes in the strength of connections between neurons (Mayford et al., 2012) in the synapses (Johansen-Berg, 2011). These are the junctions between a neuron's axon terminals – which carry the output, the signal, of a neuron – and the dendrites of another neuron – which are responsible for the input signal into a neuron. Typically, the dendrites of one neuron connect to the axon terminals of the next. In between these connections are synapses which transmit and filter the signals from the dendrites to the axon terminals. Signal sending from dendrite to axon across synapses is enabled by chemical neurotransmitters – such as the amino acids serotonin, tryptophan, and dopamine. The more dendrite and axon terminal connections there are between neurons, the more efficient the brain becomes at a given task, such as memory retrieval or repeated action. Learning influences the growth of the dendrites – making them bigger and more in number: new dendrites grow from neurons which are frequently activated, so one author notes that the more learning that is carried out, the more learning is promoted (Willis, 2006). This *neuroplasticity* – the brain's ability to change in structure and function, to form and deplete neural connections due to activity and mental experience (Hawkins, 2021; Costandi, 2016; Doidge, 2015) – allows reshaping and reorganising of the network of neuronal connections.

Learning a skill requires these plastic changes in brain function (Sugio et al., 2022), but as Judy Willis notes, if a skill is not repeated regularly, such as juggling or using a foreign language, a decrease in dendrites happens from the corresponding neurons. This "pruning" has prompted the saying, "use it or lose it" (Willis, 2006, 2). Later research has revealed that skill learnt and then abandoned for months or perhaps even years is actually easier to

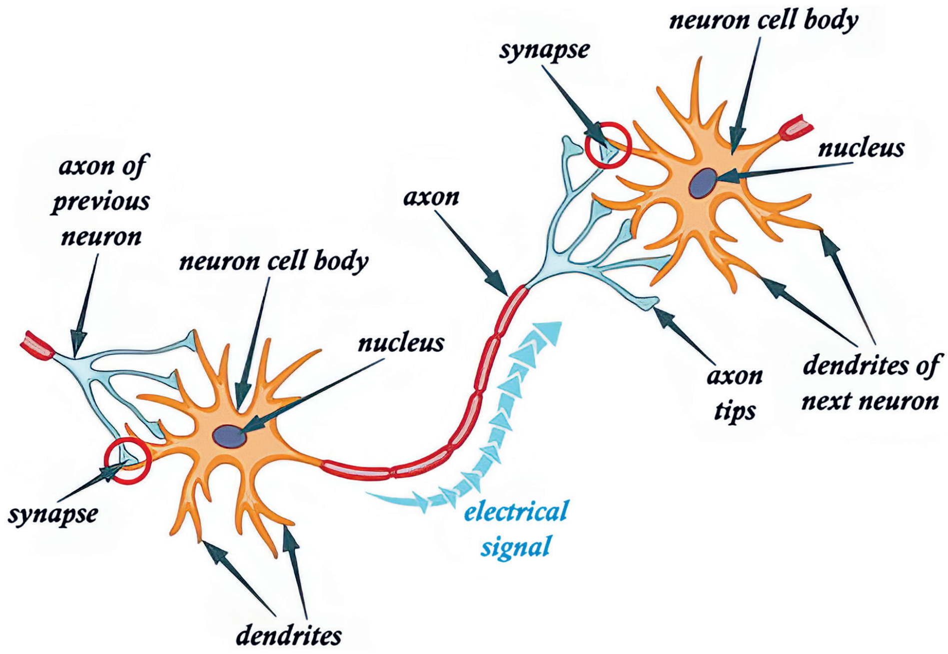


Figure 1. **Diagram showing the connections between neurons** (Shen, 2013, 1)

re-acquire, meaning that some lasting changes in the brain from learning may also occur to some extent (Vellema et al., 2019). In violinists cortical representation for the movements of fingers of the left hand was noticeably greater with professional string players than in the control groups (Elbert et al., 1995; Lotze et al., 2003) and the neuronal activity detectable through electroencephalography of violists differs from that of pianists, so much so that violinists can be identified from their neuronal activity alone (Coro et al., 2019).

Learning, skill and practice. In looking at the processes within the brain, therefore, it is possible to understand how closely learning and practice is connected; that practice reinforces what is being learnt, or what has already been learnt. Additionally, learning a motor skill poses many similarities to learning and memory in general. However, motor learning has also been described as going through *explicit* and *implicit* phases (Bracha & Bloedel, 2009). Learning a new motor skill is thought to start with an *explicit* phase, where generation of movement involves attention and awareness: movements are conscious and verbally describable. "As the learning progresses, movements become smoother, faster and automated. Eventually, well-trained movements become *implicit*, i.e. fully automatic, requiring little or no conscious effort" (Bracha & Bloedel, 2009, 2438). The same researchers go on to explain that certain types of motor learning do not require the *explicit* phase at all, such as adjustments in hand movements in response to visual feedback, where exclusive use of the *implicit* occurs. Again, on the cellular level learning a skill– such as a motor skill – and becoming proficient at it requires myelination (McKenzie et al., 2014) of the axons between neurons (see Fig. 1). Considered to be an aspect of neuroplasticity (Xin & Chan, 2020) the process of myelination in skill learning starts when a motor skill gets repeated and practised. The more this is carried out, the more electrical impulses are sent along an axon (Purves et al., 2001).

The more this repetition occurs, the more glial cells – which reside in the brain, but are non-neuronal – such as astrocytes, are prompted to release chemicals that activate other glial cells, such as oligodendrocytes, to produce myelin which then encases the axon (Bakiri et al., 2011; Ishibashi et al., 2006). Myelin is a fatty tissue and when it encases an axon, less loss of electrical current occurs and therefore increases the speed of the electrical signal carried along the axon. These speeds can range from 0.5 to 10m/s in a non-myelinated axon to speeds of up to 150m/s for myelinated axons (Purves et al., 2001). The more myelination of axons, the more efficiently an electrical signal between neurons is conducted and thus, efficiency of a skill is increased (see Fig. 2).

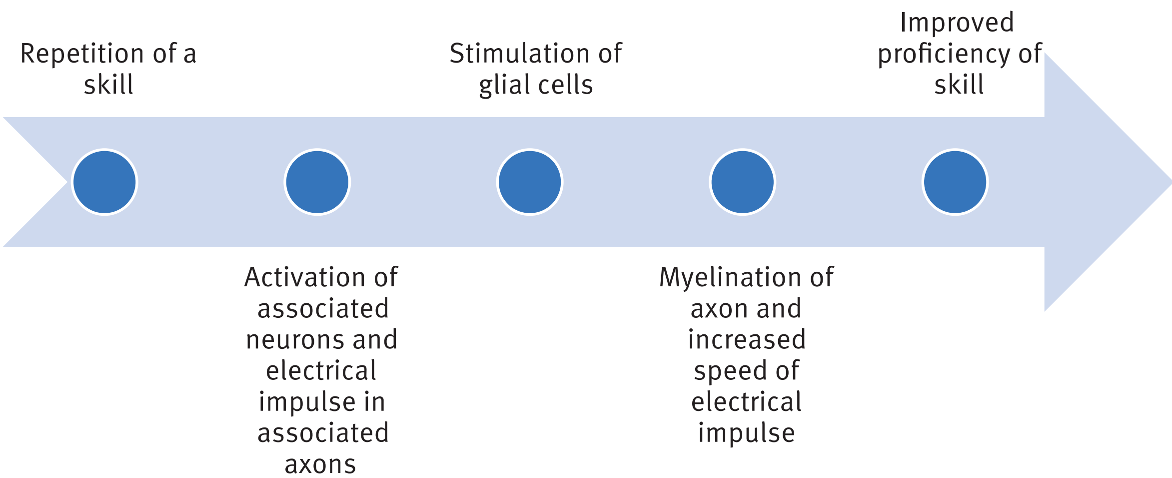


Figure 2. **The process of myelination through skill repetition** (diagram based on: McKenzie et al., 2014; Purves et al., 2001; Ishibashi et al., 2006)

Interestingly, connections have been made to the production of myelin and everyday basic needs. These include the type of foods that influence and promote the production of myelin (e.g., Langley et al., 2020), the positive role of sleep in processes involved with myelin production (de Vivo & Bellesi, 2019; Bellesi et al., 2013) and that undernourishment can be a cause of brain impairment, including impairment of the development of glial cells and myelin (Milbocker et al., 2021; Lewin, 1974). These observations support the foundational tier of Abram Maslow's theory of self-actualisation and the necessity for basic physiological needs (Maslow, 1943). In connection to neural processes, these basic needs of food, water and sleep, for instance, also support the foundations of cognition and indeed skill acquisition and development.

So, it would seem that the old saying that "practice makes perfect" can again be considered. Or maybe, as violin pedagogue Robin Kay Deverich has noted, the more something is practised *correctly*, the more it improves (Deverich, 2013), because adversely the repetition of an "incorrect" action will also strengthen the neural connections of the incorrect action.

Taking into account that the repetition of a process re-enforces neural connections, why would mental training be effective? Could this too re-enforce neural associations as in actual physical practice?

The effectiveness of mental training – theories and explanations. There have been several theories presented in the past about how the components of mental training help to improve skills. Earlier literature included the psychoneuromuscular and symbolic learning theories. The psychoneuromuscular theory posits that minute muscular movements can be detected during motor imagery – imagined movements – in the body areas corresponding with those imagined movements (Richardson, 1967). The symbolic learning theory, though similar to the psychoneuromuscular theory, does not take muscular reaction as its main premise, but supposes that mental exercise trains neural functions. It theorises that when a sequence of movements is imagined the brain encodes the patterns needed into the central nervous system (Sackett, 1934). Later on, Jean Decety's research showed the functional, statistical correlation of motor imagery versus actual movement are very similar. Using mental chronometry – which monitors the autonomic responses and measures cerebral blood flow in humans – whilst testing subjects during imagined and actual practice, he stated that "the timing of mentally simulated actions closely mimic actual movement times. Autonomic responses during motor imagery parallel the autonomic responses to actual exercise. Cerebral blood flow increases are observed in the motor cortices involved in the programming of actual movement (i.e. premotor cortex, anterior cingulate, inferior parietal lobuke and cerebellum)" (Decety, 1996, 87). He therefore concludes that imagined and executed actions to some extent share the same central structures.

Pascuale-Leone et al., recorded similarities in neuroplastic changes between mental practice and actual practice; that in learning a novel skill – in this case learning a one-handed five-finger exercise on the piano – areas in the brain responsible for long finger flexor and extensor muscles increased similarly in mental practice and physical practice. Performance levels in the mental practice group after five days equalled the physical practice group after three days, but by adding only one physical training session to the mental practice group, the performance standards equalled the physical practice group (Pascuale-Leone et al., 1995). Practically, this suggests that mental practice prior to actual practice can increase efficiency when practising physically.

The notion that similar areas of the brain are activated during imagined, or mental, and actual, perceptive or physical, processes has been corroborated also by Gorgio Ganis et al., whose study of visual imagery versus visual perception using fMRI – functional magnetic resonance imaging – found that the same "neural machinery" is used in both cases – though the similarities/overlap of brain areas was more pronounced in frontal and parietal regions of the brain (Ganis et al., 2004). The frontal lobe incorporates areas that are responsible for planning actions, controlling emotions, responses and decision making and the parietal lobe is involved in the memory and placement of objects and numbers (Blakemore & Frith, 2005). Temporal and occipital regions were not so similar, leading to the conclusion that the "cognitive control processes function comparably in both imagery and perception, whereas at least some sensory processes may be engaged differently by visual imagery and perception" (Ganis et al., 2004). This is logical perhaps, considering that the images in mental imagery are not actually being seen with the eyes. The similarity of the brain areas activated during actual perception and imagery can be seen in the fMRI results by G. Ganis et al. (see Fig. 3). Figure 3 shows the similarity of the brain areas activated during actual perception and imagery in the frontal lobe. The left side of the brain is shown on the right. Each row of images above shows a different cross section highlighted at the top right of the picture. The three columns show brain activation for actual perception, mental imagery and the contrast: perception minus imagery. Here in the frontal lobe, there is 100 percent overlap of actual and perceived imagery (see Fig. 3). It is interesting to note that the same study mentions that during visual mental imagery, information required for its "perception" is drawn from the long-term memory. When images are seen "in the mind's eye", information is being drawn from that which is stored in the long-term memory (Ganis et al., 2004). Since similar access to long term memory has been identified as being required in the learning process, it is again possible to identify a connection between mental imagery, the training of it and its relevance in the teaching and learning process.

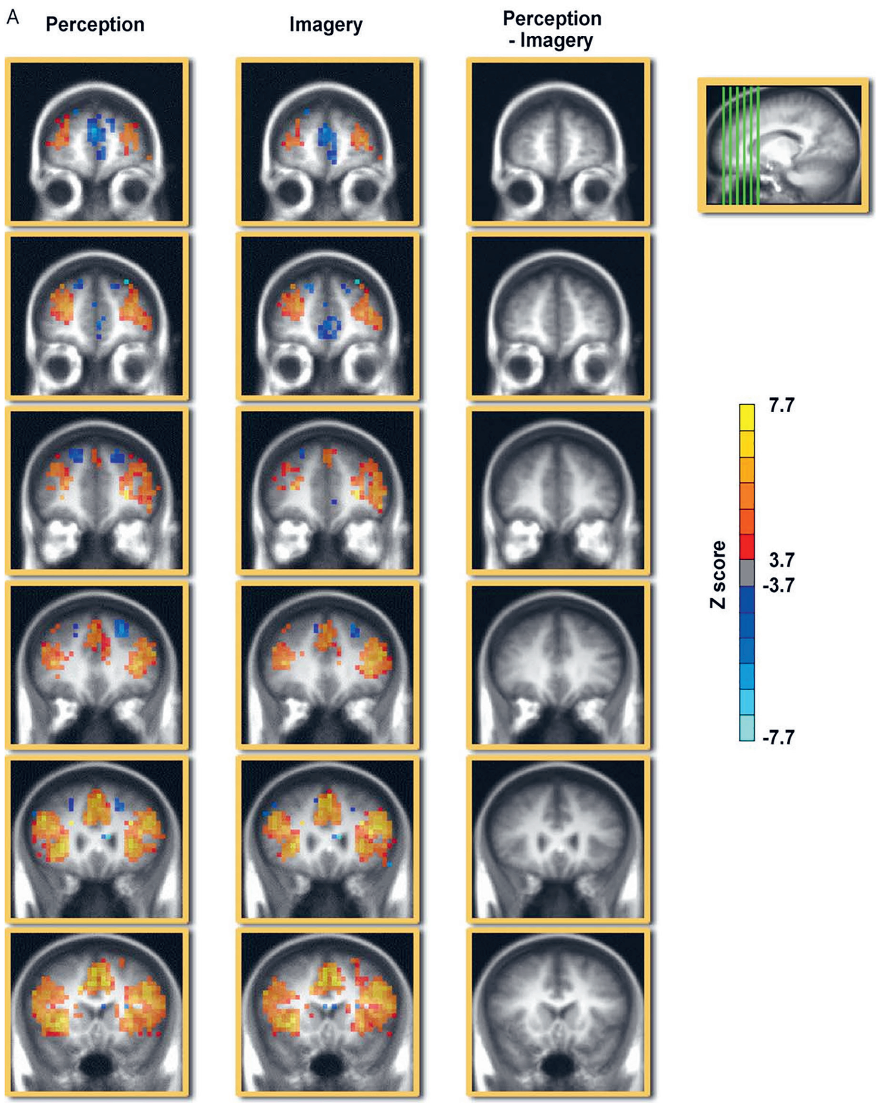


Figure 3. **An example of the fMRI produced by G. Ganis et al.** (Ganis et al., 2004, 231)

In the field of auditory imagery, Robert Zatorre and Andrea Halpern have noted that from a wide array of studies using various analysis techniques, including MEG, PET and fMRI, it can be seen that all results in the studies converge in one area: "that neural activity in the auditory cortex can occur in the absence of sound and that this activity likely mediates the phenomenological experience of imagining music" (Zatorre & Halpern, 2005, 9), which was also mentioned by later studies (see Bastepe-Gray et al., 2020). So, not only are similar brain activations noted in visual perception and visual imagery, but also in imagined sound and actual, heard sound. Interestingly, similar brain regions have been noted in auditory imagery and areas identified when listeners listening to music anticipate melodic lines during listening processes (Marion et al., 2021), again indicating the connection to imagery and neuronal processing in everyday circumstances. Additionally, different areas of the brain are activated depending on the type of music imagined. Music with words, for instance, shows bi-lateral brain activation, because the music and text are imaged simultaneously (Zatorre & Halpern, 2005). Imaging purely instrumental music on the other hand, shows activation in the right auditory cortex – which correlates with the pitch-processing role in this area.

Studies have shown that auditory and motor imagery is often combined – so-called "multimodal mental imagery." When a musician imagines a piece of music using primarily auditory imagery, concurrent motor imagery may also be experienced (Hubbard, 2013). Another study also explains how deliberate mental imagery activates dual auditory and motor areas (Zatorre et al., 2007). Even purely listening to music can initiate combined imagery. One study found that when pianists listen to music they have knowledge of performing themselves, brain activity in the primary motor regions relevant to the finger that would have produced for each of the notes can be noticed (Haueisen & Knösche, 2001). Additionally, perception in one sense mode can initiate imagery in another, which far from being an abstract phenomenon, is also experienced in everyday circumstances – such as by looking at a coffee machine that usually makes a certain noise. The perception of the coffee machine initiates imagery of its sound (Nanay, 2018). This dual perception-imagery phenomenon has also been observed in a study which revealed that when professional pianists watch a silent video of someone fingering piano keys their auditory areas of the brain are activated during observation (Haslinger et al., 2005).

It can now be understood from considering the combined literature that imagined and actual, perceived images share many of the same neural areas; that these processes are based on natural and often spontaneous mental processes, including planning of movements, melodic anticipation, and connection of different imagery types, but that they can be used and manipulated consciously. The success of mental practice, therefore, could indeed be explained by the resultant increased use, and therefore strengthening of neural structures in those areas. This would certainly seem to illustrate how the methods used in the ancient text of *Ad Herennium* (see Yates, 1966) and contemporary methods of mental training and rehearsal were and are so successful.

But can neuroscience explain why the negative mental imaging of a task results in reduced performance of that task? This is not presently explained in the literature on mental training.

Effects of negative mental imagery – explanation in neuroscience. Studies have shown that areas of the brain active during negative imagery act as a "suppressor" to information retrieval from long-term memory needed to utilise successfully the processes connected to mental imagery (Motoyama & Hishitani, 2016; Hishitani 1993, 1995, 2011). The area of the brain identified as the suppressor is the posterior cingulate gyrus, which has also been identified as the area associated with episodic memory retrieval and pain (Nielsen et al., 2005). Indeed, so-called "mental blanks," where a subject's mind would suddenly go blank (Hirsch et al., 2006) and increased anxiety (Thunnissen et al., 2022) in public performance have been recorded by those using negative mental imagery prior to performance.

It has been noted that the posterior cingulate gyrus is largely deactivated in experienced meditators (Brewer et al., 2001). These observations are useful, seeing as they provide a partial explanation as to why negative imagery is detrimental to performance. If access to the areas of the brain needed for imagery are suppressed, then sufficient information from memory for imagery creation cannot be accessed. Whereas being in a psychological state which does not activate these areas, enables the opportunity for successful mental imagery, as in meditation, but also necessary for mental training, and ease of performance.

In the field of psychiatry, negative imagery has also been acknowledged as producing a state of anxiety and reduced results in public performance. In a study of the effects of negative self-imagery on usually confident public speakers, there was more post-event negative self-judgement and reduced performance in those who were asked to use negative imagery, plus they experienced increased anxiety at the time of the performance itself, compared with the control groups. This observation of anxiety prompted the researchers to ask which aspect was more responsible for the reduced performance: the negative imagery itself, or the anxiety produced by the negative imagery (Hirsch et al., 2006). This would seem to be a valid question, considering the effects that anxiety has on learning and ultimately on the performance of skills. Indeed, stress, according to Bruce Perry, results in the activation of the limbic system in the brain. This regulates what has been termed the "fight or flight" mechanism – a basic instinct that is also common to reptiles and designed for self-protection. It has the ability to filter out any information considered non-critical for the purpose of survival, making it difficult to learn and retrieve stored information (Perry, 2006). Indeed, research has shown that the posterior cingulate gyrus – the neural suppressor – has extensive connections with the limbic regions (Maddock, et al., 2002). High level, for example repeated, prolonged or exaggerated activation of the amygdala – a part of the limbic system – through anxiety has also been recorded as having a direct negative effect on cognitive ability, preventing the proper functioning of the prefrontal cortex (Arnsten & Goldman-Rakic, 1998). As already mentioned, the areas of this cortex are responsible for the registering of new information and short-term memory, whilst the medial area of the prefrontal cortex is necessary for decision making, motivation and memory retrieval (Pillay, 2011). Other research has shown that mild to moderate stress that is perceived as uncontrollable by the receiver of the stress (Arnsten & Goldman-Rakic, 1998) and also chronic exposure to uncontrollable stress (Woo et al., 2021), impairs prefrontal cortical function and additionally has been associated with activation of the amygdala within the limbic system and fight or flight responses (Yohn & Blendy, 2017). This, as already described, does not enhance learning and performance of skills. Another effect of stress has been noted in the form of increased muscle tension due to an increase of sympathetic nervous system activity (Perry, 2006). In violinists this could lead to faulty technique and the onset of incorrect, neurological, psychological and physical habits in students.

So, by considering the combined literature, it would seem that a sequence of events can be identified; that negative mental imagery sets off a set of mental processes that results in mental blanks in performance situations and difficulty learning in pedagogical ones. These processes could be compared to a "domino effect" – a cascade of spontaneous mental processes which are effectively uncontrollable by the conscious mind (see Fig. 4).

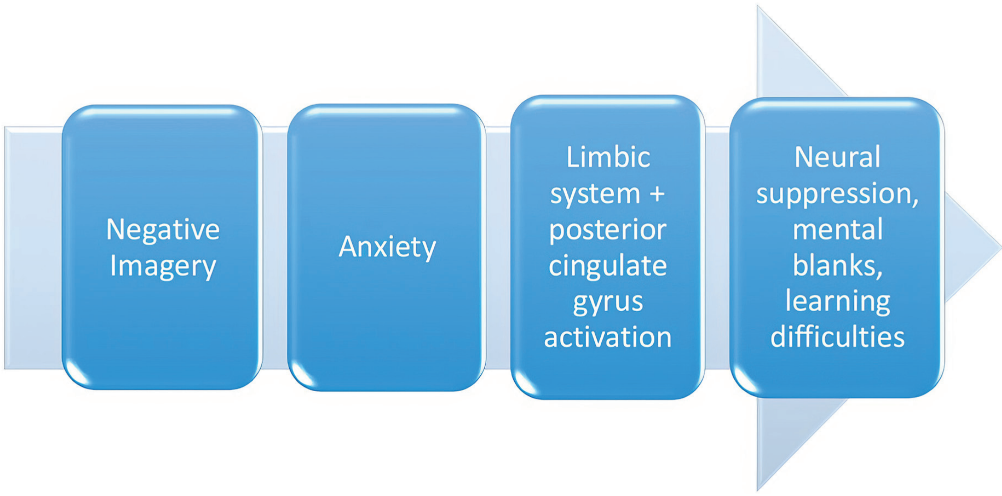


Figure 4. **The "domino effect" of negative mental imagery** (diagram based on the combined scientific theories of: Morris et al., 2005; Hirsch et al., 2006; Thunnissen et al., 2022, Perry, 2006; Maddock et al., 2002; Hishitani 1993, 1995, 2011; Pillay, 2011)

Yet, it is directly in the school environment that educational traumas are frequently – and often inadvertently – received by students (Gray, 2015), making future learning more difficult (see Perry, 2006). Whilst it has been noted that activating a student's multiple associations and relationships at the time of learning, including emotional experiences governed by the limbic system because it generates greater brain cell activity and can then be more easily stored and retrieved from long-term memory (Willis, 2006), this emotional experience should not be traumatic. It is therefore necessary for teachers to be aware of the aspects that help and hinder the learning process for instrumental skills to be learned stably and for the improved acquisition of broader cognitive skills. This, of course begs for an individual approach to teaching – since what may be a benign experience for one student may be traumatic for another.

Challenge versus stress. In the field of psychology, researchers have noted that a *challenge*, as opposed to *stress*, can indeed be helpful (LeFevre et al., 2003), especially when a challenge is just out of a learner's reach; a "step" that is small and manageable has been identified as advantageous to learning, for example (see Pillay, 2011). In a pedagogical situation, Lev Vygotsky's zone of proximal development, as outlined in *Mind and Society*, acknowledged the assistance of a more knowledgeable other, perhaps a teacher or a peer, in expanding and in reaching this next level of learning and development (Vygotsky, 1930) and therefore could be regarded as encouraging the idea of expanding learning with a challenge presented to the learner. From a psychological point of view, the assistance of a more knowledgeable other could be regarded as helping to reduce "cognitive uncertainty," which has been identified as a common attribute in learning, where cognitive development is accompanied by only a relative degree of certainty (Acredolo & O'Connor, 1991), and where the learner may experience a mental resistance to learning or assimilating new information. Uncertainty has been described as subjective cognitive or mental experience of human beings, resulting from a perceived lack of knowledge; a metacognition that represents the conscious awareness of not knowing something (Anderson et al., 2019).

Considering that cognitive uncertainty would seem to be relatively normal in the learning process, which could be connected to the solving of problems and presenting the students with challenges, this should be distinguished from learning from traumatic experiences. These make lasting changes to the brain – so much so, that children who have learned in a stressful environment receive alterations to their developing brain which can persist to adult life, resulting in a lifetime of anxiety, hypervigilance and cognitive distortion (Perry, 2006). Whilst studies have shown that stress or anxiety caused by an upcoming stressful event can actually motivate and increase performance through stimulation of the amygdala – a part of the limbic system (Dhabhar, 2018) – it can do so only up to a certain point in time, when it can then backfire, causing burnout (Pillay, 2011). The cause of burnout has been identified in a psychological context as "prolonged response to chronic emotional and interpersonal stressors" and is "defined by the three dimensions of exhaustion, cynicism, and inefficacy" (Maslach et al., 2001, 397).

So, from this multi-disciplinary standpoint, it now appears that the basis of mental training can be more clearly established. Mental training consists of the manipulation of mental images that are stored in and retrieved from long term memory and can be adapted in working- or short term- memory. Learning grows dendrites from neurons, and the actual/physical or mental rehearsal or repetition of a task strengthens these dendral-axonal connections between neurons and help to encase axons in myelin, eliciting faster movement of electrical impulses between neurons. Mental training and actual physical training share brain areas, suggesting that both the mental and physical conditions strengthen neural connections, and thus enhance learning. Additionally, the basic mental images and their manipulations need to be positive. But what insights can be gained from neuroscience concerning teacher-student interaction in the lesson situation?

An aspect of teacher-student interaction. Since it can now be understood that the mental imagery needed for mental training is stored in the long-term memory, teachers need to be aware that the experience gained by students in lessons and concerts, etc., will be partly drawn upon during the mental imagery manipulations required in later mental training sessions and indeed in later life. These experiences in pedagogical situations literally give fuel for student mental and actual imitation. Rudolf Steiner notes in many of his works that an important and integral part of child development is imitation (e.g., Steiner, 1923). Additionally, Albert Bandura's famous "Bobo doll" experiment (Association for Psychological Science, 2013) and his concept of "modelling" from his *Social Learning Theory* (Bandura, 1977) illustrated the impact of imitation in increasingly technologically present, and therefore also symbolically-influenced, environments. Indeed, the moment of interaction between teacher and student is an important aspect in pedagogy – and it is clear, according to neuroscience and the discovery of mirror neurons, that this interaction and imitation is not limited to young children, but also present throughout life.

Mirror neurons have been identified as "multimodal association neurons that increase their activity during the execution of certain actions and while hearing or seeing corresponding actions being performed by others" (Keysers, 2009, R971). In their article entitled "Social Intelligence and the Biology of Leadership," Daniel Goleman and Richard Boyatzis note that the emotions and actions of leaders prompt followers to mirror those feelings and deeds (Goleman & Boyatzis, 2008).

Discovered in the early 1990s by a group of neuroscientists from Parma university in Italy, these mirror neurons are located in the rostral part of the inferior premotor cortex and were found to be activated in makak monkeys not only in actual "goal-directed" hand movements – such as grasping and holding – but also when the monkey observed "specific and meaningful" hand movements made by the researchers themselves. These movements included "placing or retrieving a piece of food from a table, grasping food from another experimenter's hand, and manipulating objects" (Pellegrino et al., 1992, 176). Thought to be based on an instinct of survival and social organisation, mirror neurons are thought to have an important role in imitation learning in humans too. Studies show that similar neurons exist in humans, that actions – even without clear intention – or a sequence of actions that may or may not amount to an intention are mirrored by the observer in the corresponding motor areas of their brain (Rizzolatti & Craighero, 2004). It would seem that this could link to the theory and observation in skill learning – that some motor learning happens purely implicitly.

Interestingly, studies have also shown that mirror neurons are not only responsible for the imitating of motor actions, but also facial actions – in particular, with the mouth. These facial actions, including biting and sucking, ingestive and communicative actions activate the mirror neuron system (Ferrari et al., 2003), and this finding has given fuel to the notion that mirror neurons enable the understanding and perception of emotions; that mirror neurons can send messages to the emotional systems in the brain (Iacoboni, 2009). Indeed, a television documentary aired in 2005 documented a study where a person being scanned in an fMRI scanner was shown pictures of humans showing different facial expressions. The results showed not only activation of brain areas where the associated mirror neurons were located, but also activation of the brain areas responsible for the corresponding emotion of the picture shown. As Iacoboni reported in this documentary, mirror neurons facilitate communication between people on a very simple level (Reiniger et al., 2005). This aspect of basic, non-verbal, communication and interaction, plays an important and large role in pedagogy both consciously and subconsciously and potentially also with mental training within the pedagogical process. However, the research of the mirror neuron system can help to illustrate that the mirroring of actions and emotions is indeed a two-way process; that teachers can be as much influenced by the actions and emotions of the student as the student is by the actions and emotions of the teacher.

Audio-visual mirror neurons. Interestingly, audio-visual mirror neurons have been identified in the ventral pre-motor cortex (Kohler et al., 2002; Keysers et al., 2003) where not only actions are processed by the observation of actions, but also the processing of actions by the perception of the sound connected to those actions. More specifically, this means that many of the same neurons in the premotor cortex are discharged by the sound associated to an action as they are in the observation of the action itself, or indeed the performance of it (Kohler et al., 2002). As the researchers explain: "These audiovisual mirror neurons code actions independently of whether these actions are performed, heard or seen" (Kohler et al., 2002, 846).

Integration of observation into mental training. As already noted, the use and development of the concept of mental training did not originate in a pedagogical situation. Similarly, the latest research integrating the concepts of the mirror neuron system has been developed outside of any pedagogical system. But currently mirror neuron system-inspired programmes are now being seen in therapeutic intervention and rehabilitation. In one recent study, mental practice was combined with "action observation training" in stroke rehabilitation (Cha et al., 2015). The "action observation training" used in this and other research was created in direct response to the research on mirror neurons and their involvement in motor learning (Sarasso et al., 2015). Earlier studies had theorised about and anticipated the success of combined observation and mental imagery within therapeutic settings (e. g. Mulder et al., 2004), and although some literature on mental training in sport and music has included the aspect of observation (e. g. Hale & Crisfield, 1998), this aspect of mental training is now being supported and scientifically tested in other fields. Indeed, mental imagery and this "action observation training" combination is very similar to many mental training routines.

The concept of mental training in pedagogy. After considering the psychological and neurological basis of mental training, it is now possible to reflect on the current scope of mental training and its potential for use in a pedagogical environment. It can be seen that mental training is based on the use of mental imagery, that although the concept of mental training is generally regarded as being for self-improvement of already-trained practitioners, mental imagery is a part of everyday thought processes and experience.

Since the pedagogical process could be regarded as facilitating self-actualisation, in the Maslovian (Maslow, 1943) and Rogerian (Rogers, 1961) sense, the fact that mental training itself is based on the concept of self-improvement could indeed be regarded as positive also in a pedagogical setting. Rogers believed that each person had a "self-actualizing tendency;" that students "wish to learn, want to grow, seek to find out, hope to master, desire to create" (Rogers, 1961, 289). Mental training, which encourages the conscious use of the planning of action and of sound, directly develops an awareness of personal goal-setting and motivated, self-directed learning. Importantly, this process would seem to encourage the use of self-assessment: for instance, comparing the ideal sound, or ideal movement created in the imagination with the actual movement or sound which is produced practically reduces the need for external evaluation. This principle links to the idea in pedagogy of self-nurturing (Latvian: *pašaudzināšana*) (Špona & Čamane, 2009). Indeed, a reliance by the student on external evaluation, and where it is not clear for what purpose something is being learnt, for instance, can be linked to the stress theory mentioned earlier (Arnsten & Goldman-Rakic, 1998). This external evaluation could indeed become a stressor perceived by the student, consciously or unconsciously, as uncontrollable. Again, the idea of the needs of safety outlined in Maslow's hierarchy of needs (Maslow, 1943) and Rogers' unconditional positive regard (Rogers, 1961) are relevant in this context. So, it would seem that part of the task of incorporating mental training in the pedagogical process would be to encourage an environment that is congruent to developing this awareness of self-assessment; in helping the student create the concept of the "ideal" in a creative and personally relevant manner. Indeed, the concept of mental training, could be regarded as helping to foster an environment congruent with person-centred learning.

Whilst mental training in sports and to a large extent in music has been developed to help perfect and practise a skill, it is important to note that its main component – mental imagery – has also been connected to inventive, creative thought (Thomas, 2016). The mental planning of activity encourages hypothetical scenarios – where mental experimentation of sound and movement can be carried out and personally-created musical interpretations can be devised. It encourages creative learning, where everything the student imagines can be tested – such as in developing musical interpretations and phrasing, in experimenting with alternative ways of reaching the imagined notes, for example. It can help create a quasi-constructivist learning environment, where the teacher becomes a catalyst or facilitator of discovery, but not the director or evaluator of it (e. g. Bruner, 1961).

With the alternation of mental and physical activity that is used in the skill improvement aspect of mental training, it is possible to see that mental training helps to develop a conscious connection between mental and physical activity. In this respect, comparisons can be made to activity theory, which identifies the role of a “psychological tool” for a subject – a teacher, a student, for example – in attaining an object or goal (Vygotsky, 1930). This tool is described by Vygotsky as being a device for mastering mental processes and in such a context mental training itself could be considered as being such a tool that helps to bring to awareness these mental processes or *higher mental functions,* as he labelled them. In A. N. Leontiev’s writings on *Activity and Consciousness*, he notes that a mental activity happens first practically, involving external processes which, on becoming internalised, then alters or transforms the external process. This external process can then become more general and contracted (Leontiev, 1977). In mental training, a similar process can be traced. Whilst the literature in mental training indicates that the process may begin with the mental condition (e. g. Klöppel, 2010), we know from neuroscience that this condition can be based on past physical experiences residing in the long term memory (Hishinati, 1993). This alternation of mental followed by physical aspects can be found in mental training routines (e. g. Rubin-Rabson, 1941; Klöppel, 2010) and where the deliberate use of mental rehearsal is added to physical practice (Connolly & Williamon, 2004). And, similar to A.N. Leontiev’s observations, mental training publications have noted the transformation that may occur in physical skills after each mental representation of them. In the case of learning and perfecting vibrato on the violin in this way, the arm, hand and finger movements may indeed transform by *contracting* – that is, become smaller and more efficient – during the mental training routines, in just the same way as A. N. Leontiev describes an action with the use of a mediator, a mental “tool.” In a similar manner, David Kolb’s cognitive-constructivist theory of *Experiential Learning* describes a similar process of transformation. He describes how an activity, which he labels as a “concrete experience”, can be reflected upon and then conceptualised, where planning and adjustments are made mentally, then actively experimented with, which then becomes an adjusted concrete experience (Kolb & Kolb, 2012).

In effect, mental training develops a sense of metacognition – that is, cognition about cognition. An awareness and understanding of the cognitive processes associated with appraisal, monitoring and control of cognition, the basis of which can be found in both pedagogy (e. g. Favell, 1979) and neuroscience (e. g. Fleming & Lau, 2014).

So, as can be seen, the scope and purpose of mental training ranges from skill development to creative and personally relevant mental imagery and the use of cognitive processes in a conscious manner. Its essence can integrate concepts found in neuroscience, psychology, and pedagogy (see Table 1). This unity can strengthen each concept and help to understand that in fact each component in each field can assist in the motion towards the ideal of student self-actualisation.

Table 1. **Comparison of concepts in neuroscience/psychology, pedagogy and mental training**

Neuroscience / Psychology	Pedagogy	Mental Training Component
The need for food and sleep (e. g. for brain development, neuroplasticity and myelination of axons between neurons) (e. g. Lewin 1974; Milbocker et al., 2021) and stress free environment for effective activation of frontal lobes needed in learning (Pillay, 2011)	Hierarchy of needs – physiological and safety needs (Maslow, 1943)	Relaxation, sense of ease (e. g. Klöppel, 2010)
Cognitive uncertainty (e. g. Acredolo & O'Connor, 1991) and fear of leaving homeostasis	Acceptance, genuineness, understanding to encourage feeling of safety to explore inner world (Rogers, 1961)	Relaxation, sense of ease (e. g. Klöppel, 2010)
Effects of negative mental imagery and associated stress (Thunnissen et al., 2022; Hirsch et al., 2006)	Thought processes: beliefs and mental hypotheses (Dewey, 1909)	Positive versus negative imagery (Morris et al., 2005)
Mirror neuron system (Rizzolatti & Craighero, 2004), activation of brain centres connected to actions being observed (Hirsch, 2006)	Bandura – "Modelling" in *Social Learning Theory* (Bandura, 1977)	Observation of own and others' performances (e. g. Hale & Crisfield, 1998)
Strengthening of neural connections (e. g. Willis, 2006) and myelination of axons between neurons (e. g. McKenzie et al., 2014) through frequent activation and learning – mental or physical. Less brain activation in accomplished tasks	Activity theory, the theory of interiorisation and exteriorisation (Vygotsky, 1930; Vygotsky, 1987; Leontiev, 1977) processes happen 1st practically, get internalized, after which, external processes become more contracted.	Alternation of mental and physical practice (e. g. Klöppel, 2010)
Mental imagery derived from long term memory (Hishitani, 1993)	Activity theory: translation of the external world into mental representation, creating a mental model, assisting in personal orientation in external world (Leontiev, 1977) Mental imagery and personally-relevant mental imagery in memorisation (Luria, 1968). Use of symbols in thought and memory (Vgotsky, 1930b)	Mental rehearsal in the memorisation of music (Connolly & Williamon, 2004)
Multi-modal learning (Willis, 2006)	Experiential learning and reflective thought (Kolb & Kolb, 2012)	Awareness, differentiation and combination of imagery modes (e. g. Klöppel, 2010; Connolly & Williamon, 2004)

Neuroscience / Psychology	Pedagogy	Mental Training Component
Student-centred situations, where stress is not perceived as uncontrollable by student (Arnsten, Goldman-Rakic, 1998). Metacognition (e. g. Fleming & Lau, 2014)	Self-evaluation, self-nurturing *(pašaudzināšana)* (Kolb, 2012; Špona & Čamane, 2009; Rogers, 1961). Student-chosen learning contexts (Engerstrom, 1987). Metacognition (e. g. Flavell, 1979), construction of personal world models through imagery, action and language (Bruner, 1964)	Comparison of imagery versus physical realisation (Klöppel, 2010; Green& Gallwey, 2015)

Implications. In considering the combined basis of learning in neuroscience and psychology together with the concepts and techniques of practical application in mental training, similarities to general pedagogy can be drawn – particularly in connection with cognitive, constructivist and humanist pedagogical aspects. Yet, it is the interdisciplinary aspect that can help to highlight any areas of non-clarity within pedagogical theories, elicit a new interpretation or emphasis on certain attributes of them, and help to indicate how the theories could be applied in practice. The awareness of the existence of cognitive uncertainty, for instance, may help educators to understand that student resistance to learning new information is not an issue with student attitude, but based on a common mental attribute in human beings. This awareness makes it easier to empathise with the student and apply a humanistic approach, where the educators know and believe in the good of the student, where the needs and the feelings are central (Gudjons, 1998) to the learning process. Cognitive uncertainty then could be remedied by providing an environment that encourages a feeling of safety – so the student may understand that briefly leaving a state of current homeostasis with expanding knowledge and skills will not be uncomfortable. Additionally, educators can be aware not to introduce unnecessary conflict into the pedagogical situation, since the student needs to deal with his or her own internal conflict of cognitive uncertainty – from the process of assimilating and processing new information itself – or use of language that may induce negative imagery in learning, since this may then induce a stress response which impairs performance and learning.

In analysing the scientific literature in neuroscience on neuroplasticity and the formation of neuronal connections in learning and memory (Doidge, 2007; Doidge, 2015; Pascuale-Leone et al., 2005; Willis, 2006), the scientific literature on mental imagery in neuroscience mental imagery in neuroscience (Kosslyn, et al., 1990; Hishitani, 1993; Kosslyn, 1995; Decety, 1996; Ganis et al., 2004; Zatorre & Halpern, 2005), mental imagery in psychiatry, psychology and sports psychology (Richardson, 1967; Hirsch et al., 2006; Morris et al., 2005), mirror neurons in neuroscience (Rizzolatti & Craighero, 2004; di Pellegrino et al., 1992; Ferrari et al., 2003; Reiniger et al., 2005), stress theories in neuroscience (Hishitani 1993, 1995, 2011; Perry, 2006; Brewer et al., 2001; Arnsten, Goldman-Rakic, 1998; Yohn, Blendy, 2017; Maddock et al., 2002), stress theories in psychology LeFevre et al., 2003; Acredolo, O'Connor, 1991), motor skill learning (Bracha & Bloedel, 2009) and connected theories in pedagogy: social learning theory (Bandura, 1977), activity theory (Vygotsky, 1930a, 1930b; Leontiev, 1977), experiential learning theory (Kolb & Kolb, 2012), humanistic pedagogy (Maslow, 1943; Rogers, 1961) and mental training (Klöppel, 2010; Morris et al., 2005; Hale & Crisfield, 1998; Connolly, Williamon, 2004; Morris et al., 2005; Green, Gallwey, 2012), the following can be concluded in connection with the present research:

- That the pedagogical environment in which the learning takes place affects the students' mental processes.
- It is the teacher's role to assist in creating conditions in the learning environment that are congruent with student self-actualisation.
- That actions and emotions are mirrored and that this is a two-way process: teacher > student, student > teacher.
- That student experience received in lessons will be stored in long term memory and can be employed later by the student to create their own mental imagery formations.
- Negative mental imagery will diminish performance: deliberate imagery employed in pedagogical situations needs to be positive and experiences received in the pedagogical process needs to be positive, so that later the connected imagery will be positive.
- The language used in the pedagogical process needs to be deliberately chosen, so that spontaneous mental imagery will also be positive.
- Repeated actions – both physical and mental – create and strengthen neural connections in the brain. Thus, comprehension of correct actions and sounds is important.
- Stress can impair cognitive functions, memory and increase muscle tension, all of which adversely influence the violin teaching, learning and performance process. Teachers may be inspired to consider ways of providing creative, effective classroom environments that are free from stress.

1.2. The Specificity of Mental Training in Music Pedagogy

The exact relationship between mental training and the music pedagogy associated with this dissertation – namely, the individual instrumental teaching and learning process – is currently obscure in the literature. Despite the documented success of the components of mental training in individual studies and literature in the field of sport and music for already-trained practitioners, it has remained on the periphery of musical performance and even more so in music education. As Elizabeth Haddon notes, mental imagery, the major component in mental training, is rarely presented in instrumental method books, but considering its benefits, it should become part of formal musical education (Haddon, 2007).

There seem to be two factors that may have prevented this from happening: firstly, that mental training texts have not previously included an explanation as to how and why the methods are successful – that is, the literature does not include scientifically-based theoretical explanations; secondly, and perhaps because of the first factor, problems within music pedagogy have not been sufficiently identified as being solvable with mental training – that is, no practical need for mental training has been identified.

Yet, a main challenge in the field of instrumental music pedagogy includes assisting students to become proficient and independent musicians and working towards this in a collaborative manner that will inspire the student to continue in the learning and self-learning process life-long. That this concept or goal is based on the interplay between the physical and mental worlds of the student, and one that is shaped by learning and experience, perhaps only becomes more relevant when looking at the mental processes behind mental training and learning itself. This understanding has indeed started the search for new pedagogical approaches and can assist in recognising important aspects from older approaches, which also may not have been used routinely in music pedagogy.

This chapter will therefore not outline exactly how mental training is routinely used in music pedagogy – because it is not currently – but rather, how mental training can be adapted for use in music pedagogy and will identify aspects in pedagogy and music pedagogy that can relate to components of mental training. It will also attempt to identify how mental training in pedagogy bears similarities to, and can also help with, practical application of other pedagogies.

Construction of mental models. In pedagogy, the construction of cognitive structures has been recognised as occurring through the experience of both living and learning (Barker & Schaik, 2011). Authors Philip Barker and Paul van Schaik note how these models build and adapt throughout time and indeed throughout the lifespan through reflection, unlearning, or restructuring and exposure to new experiences. In much the same way that mental imagery has been identified as being spontaneously produced, these mental models explain a structure that is developed in the everyday process of human cognition and can help to describe the process of problem solving through the application of mental ideals and also the alteration that occurs to the mental model through application of its components (see Fig. 5).

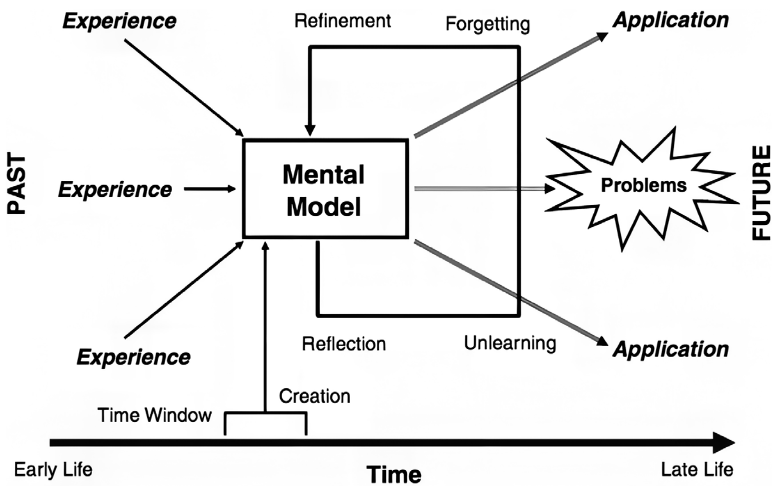


Figure 5. **Conception and evolution of a mental model** (Barker & van Schaik, 2011, 2312)

The concept of the mental model is valuable in this study since it can help to locate the application of mental training. Indeed, mental training in the traditional sense – i.e. that used with already-trained practitioners – would seem to develop a deliberate use of these mental constructions and their mental imagery-based components. That is, the mental model is consciously created and deliberately rehearsed in the mind. And, as we have seen, the mental processes connected to this these inner manipulations employ many of the same neuronal connections as their actual, physical execution (see chapter 1.1)

In the pedagogical process with mental training, however, it would seem that mental constructions both deliberate and non-deliberate, are important. The student, for example, will have already built non-deliberate mental models connected to their own previous experience. It would seem that in the pedagogical process with mental training, the teacher needs to be aware of the existence of these mental models and the fact that the experience gained in the lesson also adds to the experience upon which future mental models are built. This, of course, also coincides with the conclusions from the first chapter. The concept of the mental model also helps to illustrate the theory of *internalisation* or *interiorisation*, which has been used in many fields, including psychology, psychoanalysis, and the Vygotskian-based *Cultural-Historic Theory* in pedagogy (Podolskiy, 2011), and where external events through a process of the transformation appear as internal matter – that could indeed add to or create a mental model – and which can be *externalised*, or *exteriorized* in the outer world. This is also outlined by A. Kozulin, who notes the social-cultural influence on creative processes within the pedagogical process (Kozulin, 2003).

Thus, with the experience of practically playing the violin, or by its observation, a student may create an internal model which gets projected onto future realisations and tried out practically, at which point the internal model may be altered, or the practical realisation altered to match the internal model.

As we have seen from the basis in neuroscience and the construction of mental imagery, it is the nature of experience that dictates the success, or failure, of an external event, via the projected mental version. In a pedagogical environment, it seems that the nature of experience is set by the pedagogical approach.

Pedagogical approach with mental training. Mental training and concepts in humanistic pedagogy have common attributes. Both seek to help the student towards self-actualisation, and both acknowledge its relation to a personally-constructed inner world. It is a world that can only be accessed if one feels safe enough to do so (e.g. Rogers, 1961) and one which is accessed with progressive relaxation exercises at the start of many mental training routines (e.g. Connolly & Williamon, 2004; Klöppel, 2010). Both of these factors can be linked to research from neuroscience outlined in the first chapter, where the diminishing of stress leads to improved memory recall from long term memory and the learning of new information.

It is not envisaged, however, that pedagogical approach with mental training, especially with younger students, would start with progressive relaxation, which could seem rather too abstract, but by creating an environment, where the student feels safe enough to assimilate new and recall older information. Again, in accordance with the research in neuroscience and also the concept from humanistic pedagogy, where the student's safety needs are taken care of, a safe environment could be initiated by the teacher who attempts to use language that could produce positive or neutral spontaneous mental imagery in the student, so that stress is kept to a minimum. Additionally, linking to the research on the mirror neuron system, which can connect to mental training through the spontaneous activation of pre-motor and other preparatory areas in the brain followed by actual realisation of observed tasks and emotions, can assist in the concept of approach with mental training. This research can help to illustrate how teachers need to be aware of their emotions, that they need to be kept positive, in order to reduce limbic system activation in both teacher and student. Also, any musical demonstrations need to be accurate, so that student-imitated actions and sounds have the potential to be of a high quality. It is also partly through the research on mirror neurons that the understanding of Carl Rogers' person-centred approach can be illuminated: that the teacher's genuineness, his acceptance and understanding of the student, will be mirrored in the student's collaboration with the teacher. Neuroscientists have noted that it seems that humans are actually programmed to regard someone they are facing as someone similar to themselves (Winerman, 2005). It would seem important therefore to preserve this innate trust between teacher and student in the pedagogical process. Indeed, the subject of trust had been observed and encouraged in humanistic pedagogy as one of the basic psychological needs (e.g. Maslow, 1943).

One rare example of a text that includes a pedagogical aspect with mental training – that is, it discusses the teacher's role in this process – is in the field of sport. James Gallwey in his book *The Inner Game of Tennis* advises equality between teacher and student, suggesting using mental imagery to achieve that task.

So, it can be seen how some existing components of mental training, with the assistance of the research from neuroscience, can be identified and incorporated into the pedagogical approach. But can research in neuroscience help to indicate where mental training could further expand to be included in pedagogical approach?

Since research has shown that the short-term memory needs to be activated for effective learning of new information one psychiatrist, brain researcher and author on business leadership, actually suggests training the short-term memory by recalling recent events and achieved by asking specific time-related questions, such as those related to recent experiences (Pillay, 2011).

In fact, this approach between teacher and student at the beginning of the lesson could also help to apply C. Rogers' person-centred approach, since enquiring about recent events could be considered as being a very natural and genuine way to start the day's pedagogical and collaborative process. This could also be considered as a useful expansion of the concept of mental training in the pedagogical situation, which can help to prime the mental processes required for learning and working towards particular technical and musical goals.

The goals of the instrumental pedagogical process. In learning how to read music and play a musical instrument, just as in learning to read and recite a poem or literary tract, a student needs to be able to recognise and create internal ideals which can then be realised in a practical manner. In effect, the student needs to create his or her own internal musical voice that also conforms to the norms of musical grammar and taste. This can link to the challenge acknowledged in music pedagogy of helping a student achieve a perfect musical performance (e. g. Sprenkle & Ledet, 1961). And whilst, the goal of creating this perfect performance and the humanistic approach of a student creating and attaining their own goals may seem contradictory on the surface – because attaining this perfect musical performance is seemingly dependent on so many criteria that are usually externally driven – it would seem that the components of mental training, supported by the connected processes in neuroscience, psychology and pedagogy could potentially unify and stabilise the connection between humanistic and music pedagogies; that the highest standards of playing can be achieved and have the potential to be maintained life-long through the student's self-awareness of mental processes, and the ensuing meeting of internal and external worlds.

Mental training and skill learning. So how can the components of mental training be used to help learn the skills associated with playing a musical instrument in an inspiring and personally relevant manner? The current use of mental training, though largely designed for the already-trained musician, is precisely aimed at creating a personal ideal of sound or movement, for example, and then realising it in practice.

As mentioned earlier, current mental training processes include:

- The cognitive rehearsal of a task prior to performance of it (e. g. Driskel et al., 1994) as in *mental practice* and *mental rehearsal*;
- The conscious manipulation of mental processes, such as mental imagery, to achieve this (Mayer & Hermann, 2011);
- Awareness of the factors that affect cognitive abilities and performance – such as relaxation (e. g. Klöppel, 2010).

Since it is known that mental training involves the conscious manipulation of mental imagery, it is useful to review the different attributes and types of mental imagery:

- Formation of mental imagery utilises long term memory (Hishitani 1993) and images derived from direct experience (Cornoldi et al., 2008).
- Mental imagery can be visual, auditory, motor, olfactory or haptic in nature (Thomas, 2016).
- Mental imagery of the different senses can be combined (Thomas, 2016) – auditory, visual and motor imagery, for instance could be concurrently imagined.
- Imagery can be internal, as if participating in an action, or external, as if witnessing an action of yourself or another (e. g. Hale & Crisfield, 1998).

The fact that the mental imagery formation process requires access to long term memory indicates implications for the foundation of mental training. The necessity to access long-term memory requires a state of mind that enables easier access to memories of previous experience. As already mentioned, long term memory access can indeed be enhanced by the progressive relaxation phase, also sometimes labelled *mental preparation*, at the beginning of mental training routines (see Fig. 6). After mental preparation, traditional mental training routines often continue to the mental imaging of sound, movement and/or a combination of imagery connected to any senses used in the extract of music being worked upon. This is then followed by the actual playing and realisation of the imagined sound and/or movement. After which the process can be repeated until the music being worked upon is played accurately and precisely the same manner as it occurred in the imagination (Klöppel, 2010).

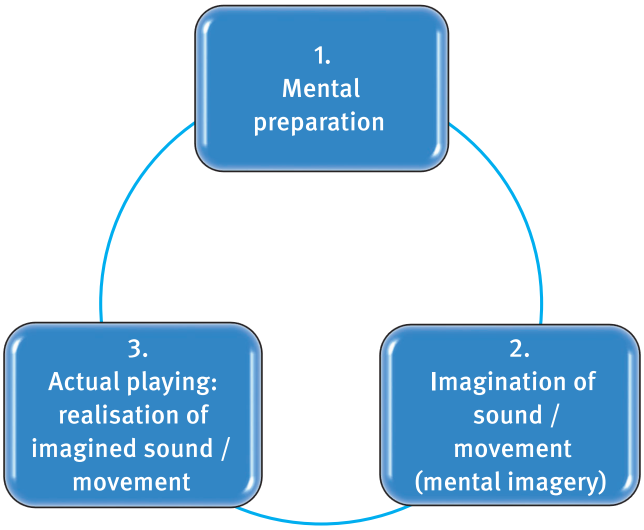


Figure 6. **Example of the process of mental training with already-trained practitioners** (based on Klöppel, 2010)

Another implication of the necessity to access long term memory for mental imagery creation would seem to be the need for previous personal and perhaps also practical experience. Renate Klöppel mentions in her book on Mental Training for musicians, that self-creation of good intonation can only be achieved if good intonation has already been heard, and to some extent experienced. This experience can then be drawn upon during mental imagery and also during actual practice when notes produced on an instrument can be compared with the ideal intonation mentally imagined (Klöppel, 2010). However, we have seen that pure observation also spontaneously activates associated brain areas (e.g. Buccino et al., 2001) and also, to a certain extent then through the mirror neuron system. In pedagogy, through the concept of the *Social Learning Theory* and modelling, it can be seen that observation alone is enough to elicit similar behaviour in the onlooker (Bandura, 1977).

It could be concluded, therefore, that the observation, as well as the practical playing experience, that a student acquires within and outside of the pedagogical process also adds to their personal experience which can be drawn upon later during mental imagery and therefore also during playing itself.

Indeed, exercises in Bruce Hale's and Penny Crisfield's book on imagery training in sport (Hale & Crisfield, 1998) use the concept of observation at the start of their mental training routine as a basis of developing *external imagery*. The exercise requires observation of a task, which can be done by watching someone else or by self-videoing, then visualising with closed eyes the task from the same external perspective as in the observation, then repeating the observation and external imagery as many times as needed until the imagery can be executed at normal speed and in full colour (See Fig. 7).

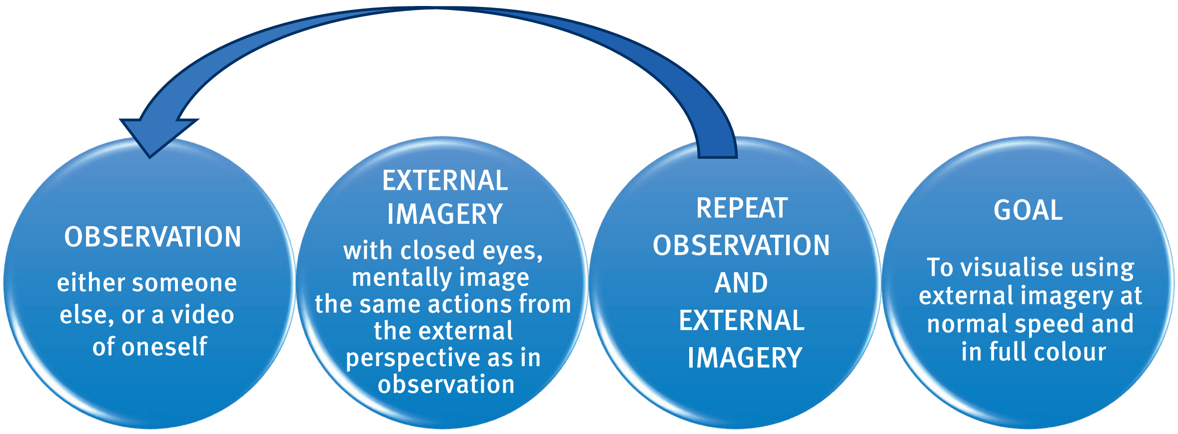


Figure 7. **External imagery exercise** (diagram based on the concepts of Hale & Crisfield, 1998)

Whilst many studies that concentrate on observation do so from a movement-orientated standpoint, some studies in the field of music have noted how movement, cognition and sound are an integrated whole. Studies in *embodied musical cognition* pose that motor capacity and perception of sound are connected – that music perception itself is based on action (e.g. Jensenius, 2007) – an observation that could be corroborated with the studies already mentioned in neuroscience, where pianists listening to a piece of music initiated activations in motor regions of the brain corresponding to the finger that would have produced those sounds (Haueisen & Knösche, 2001). Additionally, a more recent study has shown that combining mental rehearsal with associated gestures or movements increases the efficiency of the outcome of the mental rehearsal and also vividness of the imagery (Guillot et al., 2013).

Interestingly, an exercise in sport for the creation of *Internal imagery* starts with the actual experience – the physical carrying out of an action, whilst being aware of the main point of visual focus (Hale & Crisfield, 1998). This could be regarded as combining the aspect of observation together with the internal feelings from the senses of the actual movement. After this, with eyes closed, the action is repeated mentally, followed by repeating the physical action, but this time being aware of the feeling of the movements. This second execution of the action can be done with eyes closed. For enhanced motor imagery the authors recommend heavier equipment during the physical execution stage, such as two tennis rackets, to make the muscles work harder and therefore increase awareness of motor movements (see Fig. 8).

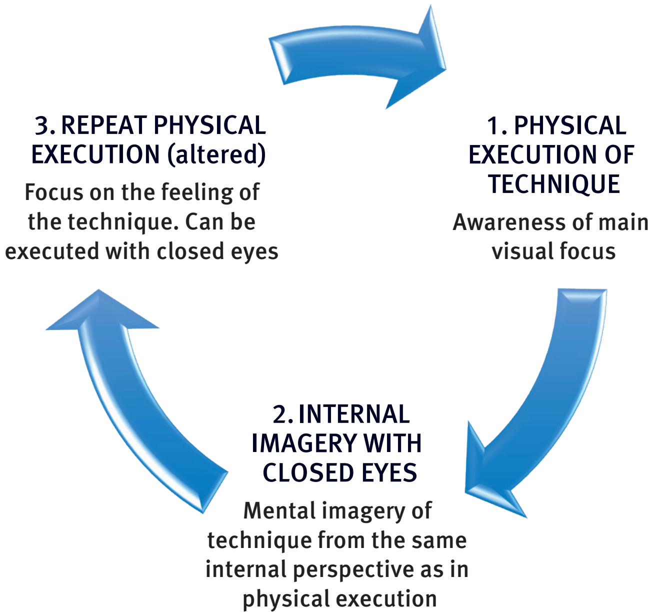


Figure 8. **Internal imagery exercise** (diagram based on the concepts of Hale & Crisfield, 1998)

The distinction between internal and external imagery and combination of imagery is also employed by Renate Klöppel in a musical context, though not labelled as such specifically as “internal” or “external” (Klöppel, 2010). Here, the internal imagery is a combination of auditory and motor. A simple four bar phrase (see Fig. 9) is presented in notational format from which the sound on a chosen instrument is imaged as auditory imagery. Then, the associated pose and movements of the hand should be imagined using motor imagery. R. Klöppel suggests that if there are difficulties in clearly imaging this, then visual mental imagery could be employed to simplify the process and then the auditory and motor imagery can be tried again. This switch to visual mental imagery effectively takes the external perspective.

Figure 9. **Example of a phrase for exercising mental imagery** (Klöppel, 2010, 30)

These exercises from both sport and music are useful in this study, since they outline the important role of observation, the differentiation between external and internal imagery, and that short phrases in a musical context are good starting points for training the use of mental imagery. Additionally, varying or switching between the imagery modes can help develop the use of imagery.

However, considering that many students will have limited experience of violin playing and that we know from neuroscience that linking new information to previous experiences (e.g. Willis, 2006) enhances learning, how can a student’s previous experience be used to enhance imagery and the concepts associated with the violin learning process?

Influence of everyday experience on imagery and practical skills. Studies in psychology describe the process of *enculturation*, the process by which individuals acquire culture-specific knowledge about the structure of the music they are exposed to through everyday experiences, such as listening to the radio, singing and dancing" (Hannon & Trainor, 2007, 466). This could indeed help to form a basis of experience upon which mental imagery can be formed. Though of course each individual has a different exposure to musical genres and the challenge would seem to be finding a way to access, or use them as a tool in the learning process; to build on what has already been experienced by an individual. The Kodaly method in music specifically took this into account when deciding how to teach musical solfège. When the method was introduced into the USA in 1969, educators were faced with the task of finding pentatonic music, upon which the early stages of the method is based, that was relevant to students in the USA (Mark & Madura, 2013). Contemporary demographics in Europe and a change in the use of influencing globalizing factors, such as technological use, may mean that it would be now very difficult to adapt a method for any specific country and so methods need to be flexible enough to be able to be adapted to each individual.

Additionally, even experience from seemingly mundane everyday events can supply material for metaphors to assist in the learning of technique and musical interpretation. This, though perhaps not commonly a part of mental training, would seem to be an efficient way of personalising the learning process. B. Green and W T. Gallway note how using the concepts from images from other areas of activity that resemble the movements involved in playing music" can assist here (Green & Gallwey, 2015). They give an example of how percussionists better understand a wrist motion if they compare it to screwing a light bulb, for instance.

It would seem that in a pedagogical situation using metaphors that are personally relevant and gained from a student's individual experience could indeed build on already-existing mental structures.

Indeed, it is very possible that each student will have experienced different social and cultural backgrounds which may ultimately have a bearing on the preferences and personal strengths experienced in the learning processes by the student. This emphasises music educator Lotta Ilomäki's observation that each student needs to be regarded individually and that uniform musical and technical requirements between students are not helpful if the learning environment is to be both constructive and collaborative in nature. The same author notes that without uniform technical demands the educator's responsibility moves towards "helping the students to clarify their musicianship goals and to acquire tools for independent learning – rather than pursuing a set of fixed skills during a particular course" (Ilomäki, 2013, 128). In much the same way as evaluating the learning potential of a bilingual child from a multicultural background on their knowledge of local, cultural and even academic norms for a particular country of their current residence would not be accurate or perhaps even ethical, how correct is it to give a student critical evaluation of their musical playing and abilities, especially in the early stages of learning an instrument? After all, the language of music may be foreign to a child, based on their previous experience. In fact, Carl Rogers noted that any kind of moral or diagnostic evaluation or judgement can seem threatening (Rogers, 1961), which as we have seen does not create an environment congruent to learning, assimilation of new and the accessing of old information.

Criticism, evaluation and mental training. W. Timothy Gallwey is one of the few authors that addresses the concept of mental training – he labelled it the *Inner Game* – in the pedagogical process. Whilst he did so in relation to adult learners, including beginners, and in the field of sport, it would seem that many of the concepts are valid also in earlier stages of learning in other fields, such as music education. He noted that criticism, even positive, could be reversed by the student's mind into negative judgement, which mirrors C. Rogers' comments mentioned earlier. Additionally, over-complimenting increased dependency on the teacher's opinion and reduced student self-criticism, whilst under-complimenting caused student under-confidence in their own abilities. He notes that students in their first term of their first year seem to need complimenting more than those later in their studies (Gallwey, 1974). Interestingly, W. T. Gallwey's observations also mirror the theory of *internalisation* mentioned earlier. He notes that teachers, even with the best intentions, can help fuel a student's "self-talk" that is often filled with self-doubt and nervousness. He notes that "over-teaching" – the teacher giving too much verbal information in lessons – can actually interfere with a student's performance. The student with his "self-talk" imitates the teacher, giving him/herself often negative mental verbal instructions that interfere with performance. Gallwey developed these ideas into a "theory of peak performance" from which he later expressed as a formula: **P**erformance *equals* **P**otential at that time to perform *minus* **I**nterference: **P = P – I**. I*nterference* comes from the student's own mind in the form of inner dialogues of self-condemnation and self-doubt, nervousness and loss of concentration. The teacher, he says, is often the source of the student's inner dialogue (Gallwey, 2012, 4:08).

W. T. Gallwey's Freudian-influenced study also looks at the way the ego is involved in getting in the way of achieving human potential in performance. W. T. Gallwey's inner, mental "game" of the is split into the two selves he labels *self 1* and *self 2*. *Self 1* is the teller, the coach the "Ego Mind," which instructs *self 2*. He identified *Self 2* as the doer, the player, which has unlimited potential, if only *self 1* would not get in the way. He therefore looked at ways of improving the relationship between the two selves, since the more *self 1* tries to "improve" the play of *self 2* by shouting instructions, and judgements, the worse the play actually gets.

He suggests calming the mind and mental imagery as a solution. He proposes that calming the mind of the student can be achieved by the teacher, suggesting that the teacher:

- Reduces verbal instructions – thus reducing the fuel for *self 1*;
- Replaces instructions with demonstrations that can be used by students as mental image references, since self 2 does cannot deal with words;

And that the student:

- Observes the teacher in action;

- Mentally places themselves into the image of the task performed by the teacher and mentally rehearsing the task a few times before performance of actual task (Gallwey, 1974).

These observations clearly link with the aspects of approach mentioned earlier: that it is the teacher's role to provide the safety that can initiate and encourage the mental processes connected to learning.

Before continuing to the use of mental training in violin texts, it is useful to sum up J. T. Gallwey's thoughts on teacher approach with mental training, since they link up with the neuroscientific, and humanistic pedagogical research mentioned earlier.

J. T. Gallwey clearly outlined the teacher's role. A teacher needs to:

- represent experience and teaching/coaching facilitates student learning from this experience.
- increase a non-judgemental awareness of what is
- have clarity of goal and choice, helping to keep the choice-maker with the choice
- inspire student self-trust to realise their potentials
- reduce interference and grow potential
- respect the other individual
- remember enjoyment improves performance and learning
- make sure that the student is thinking for himself and taking responsibility and accountability for the choices he is making (Gallwey, 1974).

Mental training components in violin texts. As mentioned previously, mental training does not currently appear in instrumental method books. However, some method books do acknowledge that the mental aspect of playing is important, though they are sometimes mentioned more as "abilities" seen as a prerequisite of a potentially good violinist, as we see in Leopold Auer's violin school (Auer, 1921), as opposed to something that can be developed in a student as a way of becoming a potentially great violinist. However, one cannot assume that just because they do not appear in texts that components related to mental training are not used in violin pedagogy. Indeed, if metaphors can be added to the scope of mental training in a pedagogical situation, then it could be argued that some aspects are included in the current pedagogical process. However, it would seem that even this aspect is neglected in the literature and has become part of the oral tradition in violin pedagogy, since the components are not yet brought together to a systemized whole.

Examples of separate instances of its use include violinist and pedagogue Pinchas Zukerman's masterclass given at the Royal College of Music in London, who stressed the importance of preparation in playing the violin, to know what is coming next and who also used the metaphor of diamonds to describe the kind of bow strokes required for *spiccato* bowing in the Tchaikovsky violin concerto (Zukerman, 2014). The metaphor effectively combines various mentally-imaged senses; haptic, for the hardness of the diamonds and visual, for their shape. This image effectively then controls the concept of the motor movement needed for spiccato – short, individual, somewhat rounded, but hard movements. Another example of more deliberate use of metaphors is in a masterclass given by Maxim Vengerov who uses visualisation, scenarios and metaphors in a positive manner to achieve musical interpretations (Vengerov et al., 2008). In this filmed masterclass, it is possible to witness the marked improvement of the students, who seem to be able to incorporate characters and musical concepts easily and instantly in their playing.

In analysing these two examples, it is possible to see that the pedagogue is demonstrating the concept of forward preparation and use of multiple senses through the use of metaphors. In the pedagogical process, however, it would perhaps be more personally relevant for the student to use their own imagery, which according to the research outlined in the first chapter could also assist in the memorisation of the music being learnt, since multi-modal associations would be employed.

Considering that the use of mental training components has a quasi-oral tradition, it is not surprising perhaps that early violin method books including those by Louis Spohr (Spohr, 1832), Heinrich Ernst Kayser (Kayser, c.1865) and Franz Wohlfahrt (Wohlfahrt, 1882), do have an element that can be linked to later mental training research: namely the exercises for beginners which require the accompaniment of the teacher playing on the violin. These duet exercises, in the case of L. Spohr and H. E. Kayser commence from the very first exercise, where the student plays open strings. Perhaps included intuitively by their authors, these methods ultimately result in the student's conscious or subconscious observation of the teacher that has been shown in later studies to be an effective method of helping students to learn more effectively, and it may also reduce the need for the issuing of verbal instructions and link to the research on mirror neurons. Duet playing with the teacher also creates a goal for the student. To be able to play with someone else, the student has the need, the goal, to play in time and in tune, for example. Alessandro Rolla, the teacher of Nicolo Paganini, devised a scale book for violin which is written in duo format – the student plays the scale – each note for four beats – and the teacher plays melodies (Rolla, 1814). In this way, students are not only learning technique – which Edwin E. Gordon says destroys *audiation* (GIMLPublications, 2011), which roughly corresponds to auditory imagery – but also learning musical harmony and to some extent interpretation, depending on the artistry of the teacher's playing. The melodies also become a distraction from the pure concentration on intonation which, as E. E. Gordon notes, seems to make intonation more difficult.

Other evidence of mental training components can be traced to Nicolo Paganini. This largely ignored fact in modern literature can be traced to an obscure violin technique book published at the beginning of the twentieth century. Though N. Paganini himself never produced a method book, one researcher and violinist called Goby Eberhardt, noted by interviewing Camillo Sivori, a student of N. Paganini, that N. Paganini rarely practised audibly and that he used to carry around a dummy violin neck to practise on (Eberhardt, 1910) (see Fig. 10).

Figure 10. **Dummy violin neck with strings** (Eberhardt, 1910, 12)

C. Sivori also told G. Eberhardt that he used a similar dummy violin himself. It has therefore to be assumed that N. Paganini and C. Sivori used and developed auditory imagery as a method of practising, whilst at the same time they presumably developed a strong feeling for motor movements and imagery of the left hand. This indeed connects the research that reported the increased effectiveness of movement with mental rehearsal. Indeed, G. Eberhardt, after suffering a stroke which restricted the use of the left hand side of his body, wrote a system for practising the violin and piano based on Psycho-Physiological Principles. He notes that practice means learning and as such is to do with mental skills and not just physical (Eberhardt, 1910). Inspired by N. Paganini's and C. Sivori's "mute playing" G. Eberhardt develops the idea that technical difficulties should not be overcome by senseless practising, but by securing a connection with internally imagined movement. He recommends doing silent exercises with the left hand on the violin which he says can prove surprisingly successful, since the hand is not distracted, or subject to variation so easily. It seems that the motor skills are more confidently executed, presumably because of the lack of actual sound. He recommended doing these silent exercises for 15 to 20 minutes in the morning. Indeed, by doing the exercises himself, G. Eberhardt was apparently able to regain control over his left hand.

N. Paganini also addressed the aspect of approach in his biography notated in German by Julius Max Schottky, and in doing so mirrors some of the observations of J. T. Gallwey nearly 145 years later.

> "You must suppress the current teaching methods which seem to act as complicated doctrines, rather than teaching how to do things" (Schottky, 1830, 276).

Another aspect G. Eberhardt was said to have learned from C. Sivori about N. Paganini's methods was the ease that things could be done with. Indeed, N. Paganini again proclaimed in his biography:

> "My secret, if I may call it that, is likely to suggest a way for the violin player to better discover the nature of the instrument, from that which they had before, and which is a lot easier than is generally supposed" (Schottky, 1830, 276).

String pedagogue and medical graduate Demetrius Constantine Dounis also advocated the importance of ease whilst practising as the first "rule" in his valuable violin method: "Violin Players' Daily Dozen to Keep the Violinist Technically Fit for the Day's Work" (Dounis, 1925). Indeed, D. C. Dounis in his violin methods stresses the importance of training the brain and memory (Dounis, 1935; Dounis, 1921). He even calls the technique "mental training" in the later book (Dounis, 1935) and suggests that this can be achieved from the very beginning of studies.

"The student should be accustomed from the very beginning of his studies to think of each movement *before* making it. He must have a distinct picture of each physical movement reflected in the brain before he makes it actual, spontaneously through will power. Technique should be nothing else but a series of brain-reflected movements" (Dounis, 1935, 3). D. C. Dounis' conclusions could be considered reliable, since his medical specialism was neurology and psychiatry.

Despite a few early twentieth century methods pointing out the advantage of the mental aspect of playing, later methods seem to be lacking in this area. One exception is a mention of it by Ivan Galamian (Galamian, 1962). Whilst I. Galamian does not clearly define mental training as a technique, he acknowledges the importance of the mental aspect in violin playing in the last chapter of his method book on a chapter on practising. He notes that students more often practise poorly, rather than well and so teachers need to be able to show students how to practise correctly, not just pointing out and concentrating on mistakes. Students, he recommends, need to keep a mental alertness and organise their practice into three parts: 1) Building time 2) Interpreting time and 3) Performance time. In "building time" (1) he notes that "mental preparation" is extremely important, describing this as meaning the anticipation of the physical action that must be prepared in the mind of the violinist before actually executing the action itself. Whilst this method echoes scientific research on mental imagery, and how mentally preparing movements uses the same brain structures as physical, it is interesting that I. Galamian envisages this mental anticipation being done at the instrument, rather than allotting a separate quasi meditative occasion for this. I. Galamian advises students to practise different rhythms for this purpose – which can be used when practising scales or the more difficult areas in the repertoire (see Fig.11).

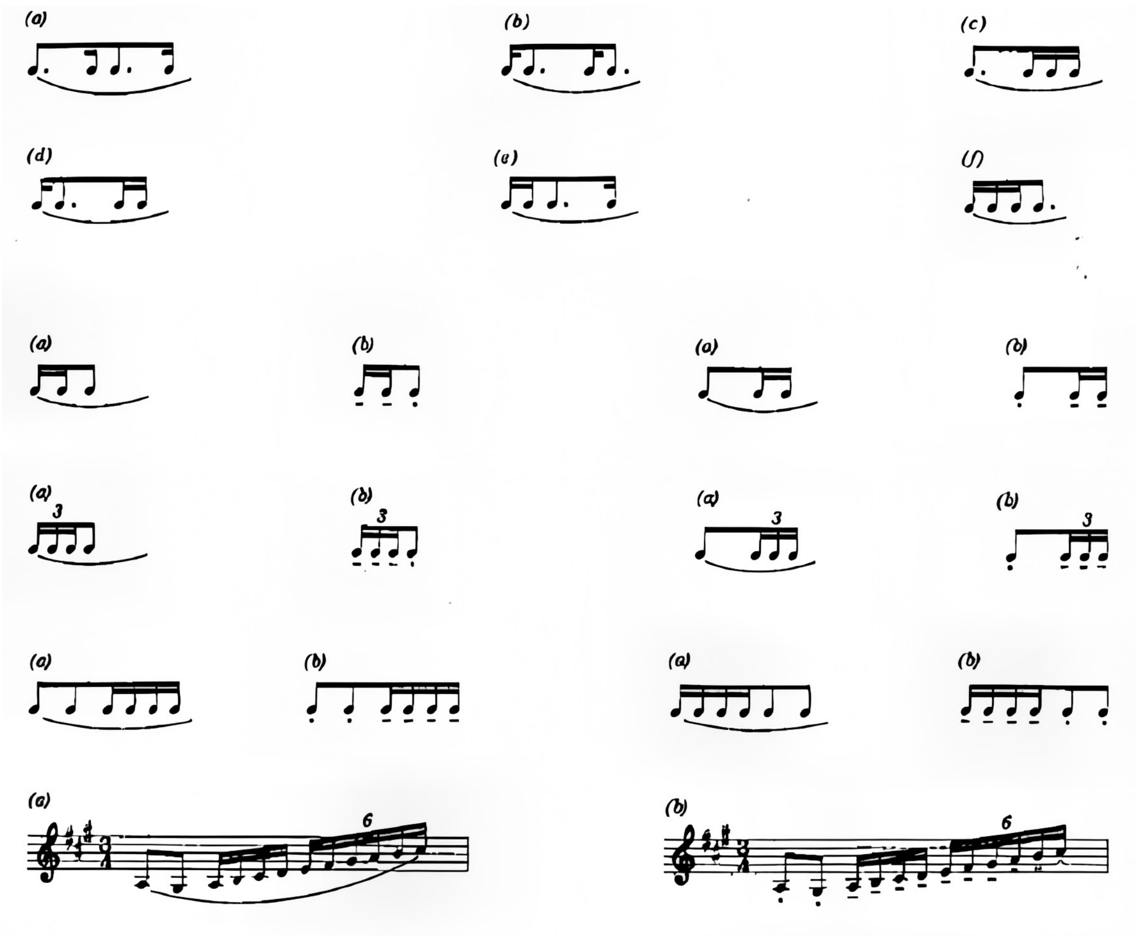


Figure 11. **Example of rhythmic shapes for practice of mental correlation** (Galamian, 1962, 97)

I. Galamian's second part of his practice routine – "Interpreting Time" – plays less importance on the mental aspect of playing, except that he noticed that students need to be able to also play through their repertoire without being disturbed by their technical problems so perform without stopping. His technique for accomplishing this, however, is externally driven by the teacher, where the student is attempting to "catch up" as best he can following a mistake, being "driven" by the teacher.

More modern methods that include components of mental training, though not perhaps designed as such, include the *Suzuki Method* (Suzuki, 1978) and *El Sistema* (Abreau & Dudamel, 2009). The Suzuki method is interesting in that it is tailored for very young students and starts without the reading of music, presumably encouraging the development of inner hearing, or auditory imagery, and involves learning by observation and imitation. *El Sistema* starts young children playing the violin without the violin at all, but with paper, homebuilt, silent instruments. The reason for the homebuilt instruments was actually a lack of money to buy real ones, but actually has, perhaps inadvertently, resulted in developing the children's mental imagery abilities which then acts as a quasi-motivator for them to graduate onto real ones. The young children sit in the positions they would in an orchestra and sing about playing their instruments in the orchestra and mime instrument playing movements with their “violins” along with their songs (Abreau & Dudamel, 2009). The children also have the chance to sit next to their older peers who already play in an orchestra, in order to observe their methods and music-making. This aspect of observation is also in accordance with mental training. This system of orchestral training was first introduced into Venezuela in 1975 to help the children off the streets and to help build collaboration in communities. Their all-inclusive backing of children to get a musical education has led to their nation-wide network of youth orchestras and the formation of the now famous *Simon Bolivar Orchestra*.

Whilst there are violin methods which include aspects of mental imagery and mental training (see Table 2), the ideas and components of mental training are still under-developed in violin pedagogy. There is no current systemisation of the components and generally no deliberate connection made to mental training. What the literature does perhaps show, however, is that the components of mental training are adaptable for inclusion in the violin teaching and learning process.

Table 2. **Mental training components identified in existent violin literature**

Component in Violin Literature	Component Mental Training / Neuroscience	Source
Metaphors	Multimodal imagery	M. Vengerov (Vengerov et al., 2008); P. Zukerman (Zukerman, 2014)
Stories / scenarios	Imagery and memorisation	M. Vengerov (Vengerov et al., 2008)
Methods for beginners with student/teacher duet components	Observation, mirror neurons	L. Spohr (Spohr, 1832); H. E. Kayser (Kayser, c.1865); F. Wohlfahrt (Wohlfahrt, 1882)
Dummy/practice violin	Mental rehearsal with movement	G. Eberhardt (Eberhardt, 1910); N. Paganini/ J. M. Schottky (Schottky, 1830); *El sistema* (Abreau & Dudamel, 2009)
Approach and sense of ease	Relaxation / calm awareness of current moment	G. Eberhardt (Eberhardt, 1910); N. Paganini/ J. M. Schottky (Schottky, 1830); D. M. Dounis (Dounis, 1925)
Demonstration of how to practise	Accurate practice leads to strengthening of neural pathways of correct movements, etc	I. Galamian (Galamian, 1962)
Preparation of physical action in mind before actual action	Imagery during and before playing	I. Galamian (Galamian, 1962); P. Zukerman (Zukerman, 2014); D. C. Dounis (Dounis, 1935)
Observation	Aural perception and projection / creation of mental models	*Suzuki Method* (Suzuki, 1978)

Yet, completely missing in the violin literature, however, would seem to be aspects of personal relevance. Whilst it can be seen that some literature uses mental imagery, the methods could inspire students to use their personal experience from other areas of life in the creation of stories and scenarios to help with interpretation and technical acquisition. This could also help students to regard a violin-playing environment as more natural and personally relevant, and therefore help to build a positive, collaborative relationship with the teacher. The common goal of both teacher and student is artistic creation, rather than being externally motivated by exams, marks or competitive thinking. The mental rehearsing of situations, tasks, exercises, not only helps with creating stronger neural pathways and more efficient learning, but also helps students create and reach goals. The aspect of introducing a calm learning environment is important for both teachers and students. Teachers need to be aware of their own role in creating a positive environment, and how to assist students in developing their own personally-relevant imagination. It would seem that teachers can inspire positivity and promote a sense of ease. They need to be genuine with themselves and others and let go of or develop past ideas into creative pathways and strive for a cooperative perfection:

- is not routinely and systematically used in music pedagogy, but that it is viable and well-suited for use in the pedagogical process;
- encourages the deliberate use and conscious awareness of interiorisation and exteriorisation – the relationship between inner mental processes and outer activity;
- can build technique and musicianship on the student's personal past experience;
- can help to create goals in the learning process: with mentally imaging a task prior to playing or performance, an internal goal is being created. This is an important detail in relation to the pedagogical process with mental training, since student use of internal goals, reduces the dependence on external instruction from the teacher and increases the personal relevance for the student;
- in music pedagogy can help to put into practice concepts from humanistic pedagogy and helps to define the role of the teacher in the pedagogical process;
- through the deliberate use of different types of imagery, can help to build mental models that can help a student towards self-actualisation.

1.3. The Characteristics of Primary School Violin Playing Skill and its Pedagogical Process

To understand the acquisition of violin playing skill in the specialist music primary school pedagogical process, it is necessary to understand both the mental-physical processes that are being employed to play a musical instrument and the developmental stage of the learner. This chapter will discuss the neuronal and physical processes behind the skill of violin playing, plus evaluate the current literature available for students in the primary school age group. Developmental aspects are discussed in more detail in chapter 1.4.

Development of the skill of violin playing. Since it has been established that learning a skill creates neuronal changes in the brain, neuronal changes identified in professional musicians can provide an indication of the skill acquisition process. Changes identified in professional violinists include larger right motor and somatosensory cortex compared to left somatosensory cortex whilst non-musicians show no hemispheric differences (Schwenkreis et al., 2007). This is consistent with the necessity for violinists to use the left hand to produce pitch on the instrument. Other studies have confirmed that this neuro-plastic change is indeed specific to violinists, since pianists display an additional *left* hemispheric change (Bangert & Schlaug, 2006), connected to the different requirements of playing that instrument. Regardless of the instrument played, various other studies have noted that the plasticity gained through learning movements is dependent on the amount of use. Movements that are regularly repeated strengthen connected neuronal circuitry, whereas circuitry weakens if movements have not been recently maintained (Classen et al., 1998). Interestingly, the same study noted that even short bursts of motor training – in this case, simple thumb movements – of 15 or 30 minutes, or as little as 5 to 10 minutes in some cases, were enough to initiate neural plasticity and proposed that these changes may represent a short-term memory for movement and as such is a first step towards the acquisition of motoric skill.

Yet playing a musical instrument such as the violin requires more than the acquisition of movements alone, it requires the player to hear, or rather pre-hear and then produce correct pitches, then recognise when a pitch or timbre needs to be altered and to do this in a sequence and timeframe that is dictated by a printed musical score (Gruhn, 2015). This process involves multiple senses including the kinetic, auditory and visual. The task of a musician would seem then to be in choosing the required technique at the required time. This could be regarded as being the *skill* of the musician. In the field of sport, the difference between skills and techniques have been discerned – that *skill* encompasses the use and choice of the correct techniques at the correct time successfully and regularly to achieve athletic objectives, whilst *technique* describes the basic movements (Mackenzie, 2001) that may be a component part of skill.

It would seem that a large part of the skill in playing the violin is connecting the auditory and the kinaesthetic or motor – a conclusion that can be drawn by analysing the literature in neuroscience.

Mental-motor-sensory processes used in learning and playing the violin. From looking at the literature on mirror neurons and audio-visual mirror neurons, it would seem that multi-sensory connections are normal, everyday procedures undertaken by the brain. Yet, studies have shown that motor and auditory structures are connected more closely in musicians than in non-musicians (Zatorre et al., 2007), and that musical training helps to develop and strengthen these connections and structures (Ellis et al., 2012). Indeed, one study found that this connection was greater in musicians with more years of practice (Palomar-Garcia et al., 2016). But since even the simplest of melodies requires precise control of rhythm and pitch which requires the interaction between auditory and motor systems (Zatorre et al., 2007), it would seem that these structures are being developed from the very beginning of learning, and so being aware of this from the beginning of studies and at the beginning of learning a new musical work could help design approaches that consciously address this connection.

So, in devising the design of a mental training routine to be used in the pedagogical situation for this purpose, it is necessary to consider the exact mental processes that are involved in playing and practising a musical instrument, such as the violin. Thus, the reason for the routine can be identified and its effectiveness determined.

As already noted, playing an instrument involves the integration of auditory and motor processes. These processes are involved in producing the sound on the instrument, in the perception of the sounds produced, and in adjusting motoric movements in response to the perceived sound. So, it would seem that performing music requires a combination of the motor system in music production and auditory processing in music perception (Zatorre et al., 2007). Thus, the production of music on an instrument requires the control of: timing – carrying out a movement at the required moment, sequencing – the ordering of the individual movements and spatial organisation of movements. The processes involved in the perception of music include pitch and rhythmic processing.

Important, and particularly relevant to this study on mental training, is to consider not only necessary connections between the motoric and the auditory developed *during* playing, but also the need for these processes to be anticipated *before* playing through "feedforward" of this. Studies have noted that this feedforward process often occurs from a stimulus, such as a musical score and as such adds another dimension to the playing and performing process – that of visual perception of the musical score. As Wilfried Gruhn points out, the visual perception of the notes being read from a musical score initiates the mental process of cognition which enables the perception of sound from a written musical score (Gruhn, 2015). In effect, it is this anticipation of sound and action – that can be represented through mental imagery – that could be regarded as being very close to the skills developed in mental training, with the exception that mental training aims to develop this process and apply it deliberately.

Yet, the anticipatory mental imagery process does not end when the playing begins. This mental, feedforward process of combined motor and auditory imagery is then followed by actual playing and production of sound, from which the player then receives multisensory feedback (Wan & Schlaug, 2010) after which the process of feedforward followed by feedback repeats (see Fig. 12). The only difference when feedforward occurs *during* playing is that it creates what Barry Green describes as a duet between the music that is actually being played and the music in the mind (Green & Gallway, 2015). Some sources have distinguished the imagery used before playing as *offline* and the imagery produced during playing as *online* (Keller, 2012). So, this duet that Barry Green refers to occurs in the *online* condition.

Based on the combined literature, figure 12 is a visual representation of the processes that occur when playing a musical instrument, such as the violin.

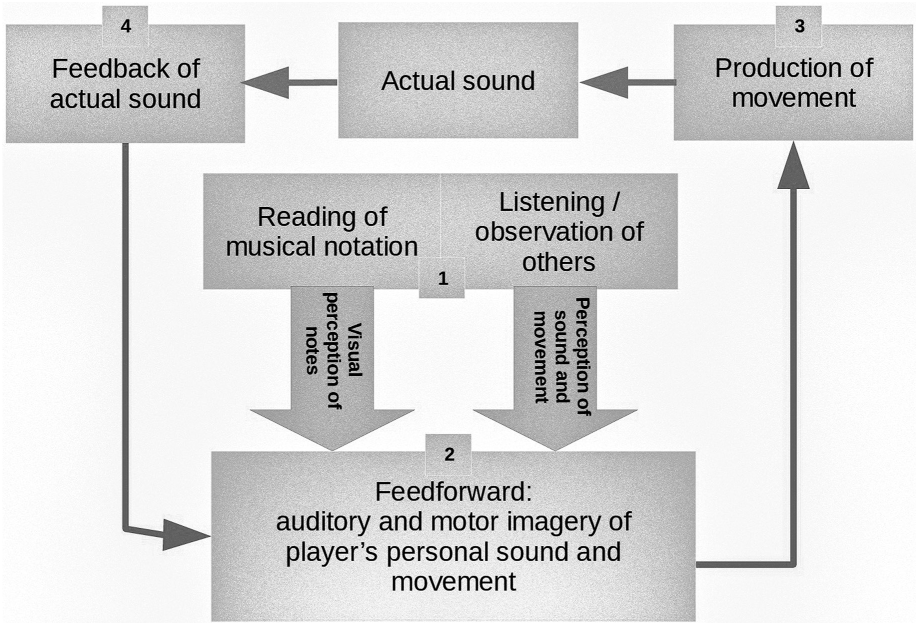


Figure 12. **Mental processes occurring in the process of playing the violin** (based on the combined concepts of Zatorre et al., 2007; Wan & Schlaug, 2010; Keller, 2012; Gruhn, 2015)

These processes can be started from either the reading of a musical score, from observation and auditory perception, or from any combination of them (box 1). Following on from this, initial "offline" anticipatory imagery is produced: feedforward of combined motor and auditory imagery (box 2). The auditory imagery projects/anticipates the player's desired sound and the motor imagery projects the techniques and movements required to get that sound. After this, the anticipated movements are realised (box 3) and the actual sound produced by the player is perceived (box 4). Feedback of the perceived sound initiates another feedforward process – which can now occur *online* – of motor and auditory processes (box 2) to regulate and correct any inconsistencies with that being anticipated and that which has actually been produced. This process, though intricate and detailed on paper, can happen in a split second in reality.

In analysing the processes involved in performance, it is interesting to note the significance of feedforward. Interestingly, it is these feedforward processes that have been identified as being less developed in novices than in professionals. In the field of sport, it is the deliberate mental representation of actions leading up to a target before taking a shot – which could be regarded as a feedforward, mental rehearsal-type process – which has been associated with behaviours in professional athletes, but lacking in novices (Frank et al., 2016). It would seem from the literature that developing feedforward and feedback processes that promote auditory-motor connections is therefore actual in the violin teaching and learning process.

As can be seen, connections between the processes of playing an instrument and mental imagery are close and have been noted in neuroscientific research (Zatorre, 2007). Though it would seem that mental imagery is not absolutely necessary for initial emergence of auditory-motor connections in studies that explore perception of rhythm and motor activations (Chen et al., 2008), the gamut of research also suggests that mental imagery can be both a stimulus for and a product of auditory-motor coupling.

So how can the development of auditory-motor, feedforward and feedback skills be consciously – deliberately – and effectively tackled in the violin teaching and learning process?

Developing auditory and motor connections in the pedagogical process. Researchers Takafumi Kajihara et al., confirm in their study interdisciplinary study that the auditory-motor coupling does indeed seem to be learned in the pedagogical process; that greater auditory-motor coupling was identified with young Suzuki-trained violin students, whose beginning stages of learning the violin takes place without the learner using musical notation, but by listening and by observation, compared to the more "traditionally" trained students in the study whose initial training had taken place with the requirement of also reading the musical notation (Kajihara et al., 2013). The literature in neuroscience concerning brain activation during observation and mirror neurons would seem to support the premise of observational, auditory learning, since brain areas associated with the actual carrying out of a task are activated also during observation and auditory perception.

The importance of listening skills has, however, also been pointed out in non-Suzuki pedagogical literature, which are recommended to be developed from the very first lesson (Fischer, 2013). Indeed, it can perhaps be assumed that the listening skills help to develop the auditory feedforward processes. Could it also be that in the learning process it is the predictive auditory imagery that gives rise to motor movement? Does auditory imagery work as a quasi-motivator for the physical action required to attain the correct note?

Violin pedagogue and author Simon Fischer notes that intonation is based on clear mental pictures and that maintaining a free and relaxed left hand enables improvement of intonation (Fischer, 2013). Additionally, Christopher Brooks notes that a violinist needs to feel physically comfortable with their instrument; that possessing a good sense of intonation may be spoilt by bad physical relationship with the instrument and that poor practice leads to inaccurate shifting of position and subsequently also non-objective listening to one's own sound (Brooks, 2007). In fact, it could be argued that if the sound produced on the instrument is not that which is has been anticipated by the player in feedforward processes – that there is essentially a mismatch between what has been imaged and what is actually played – the player may react within the feedback process by tensing the hands and/or arms, which further inhibits attainment of correct pitches. A student may therefore have a good sense of intonation, but lack the tools to rectify it and as a result continue to play "out of tune". These concepts help to confirm the notion that it is the sound, the auditory imagery, that drives the movement, and that if the violin technique is "free" enough, the player can find it easier to perform the required notes on the instrument. On another level, these concepts also link up to the previously mentioned literature in neuroscience, psychology and pedagogy: that poor or incorrect practice also creates and strengthens those neural pathways within the process of neuroplasticity for those incorrect routines. Additionally, it seems that through the sympathetic nervous system tension in the hands can also occur as a result of a stressful pedagogical approach. Also, even the comprehension that a non-desired, non-planned sound is produced may lead to a student perceiving the situation as uncontrollable and lead to further stress followed by increased muscle tensions and then further inaccurate playing.

There are very few exercises that are designed to address these problems, and directly address the concept of the improvement of auditory-motor coupling within a musical work that is being learnt. Interestingly, a small amount of historical literature connected to violin playing supports the idea of developing silent exercises – i.e. Playing an exercise with the left hand only, without the bow and without using pizzicato (see Dounis 1925; Eberhardt 1910). Constantin Dounis' exercises start with the direction to: "Cultivate at all times a feeling of absolute comfort while practising" (Dounis, 1925, 3). D. C. Dounis' first exercise requires the player to silently place the fingers in a quadruple-stop, whilst each finger in turn is exercised in a slow trill-like fashion (see Fig. 13).

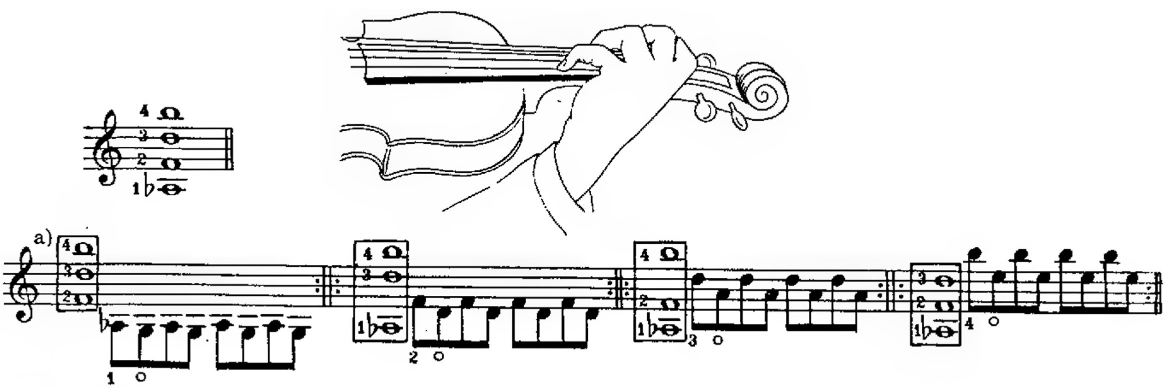


Figure 13. **Excerpt from D. C. Dounis' first exercise to be practised without the bow**
(Dounis, 1925, 4)

The effect of practising the silent exercises with absolute ease and without the use of the bow effectively reduces the distraction that a player could experience from the actual production of sound. In short, it has the effect of removing the feedback process that could, in the initial learning process, be a source of distraction and indeed stress. At the same time, it is possible that with this exercise the student strengthens feedforward and the cognitive processes connected to violin playing. Whilst D. C. Dounis in a different publication acknowledges that "technique should be a process of mental training"– i.e., that students need to have a mental picture of a movement before making an actual deliberate movement (Dounis, 1935, 3) – it is interesting that the importance of auditory concepts is omitted from both the 1925 publication and that from 1935. Indeed, there is little published discussing the improvement of a student's auditory-motor coupling connected to the musical work which is being prepared at any given time and additionally how learning and reading from a musical score can be integrated into the process. This dearth can be noted also in modern publications, despite their actuality in the early stages of the violin teaching and learning processes.

Current pedagogical concepts in violin playing. The teaching and learning process of primary school-aged violin students is concerned with acquiring the basics of violin technique as well as elements of musical theory, repertoire and interpretation. Joahims Brauns acknowledged that developing artistic and technical unity is of greatest importance in the violin class (Brauns, 1969). But can this be achieved in the primary school age-group?

In *El Sistema*, musicality is developed along with the technical from the start of learning. In this method, young preschool potential string players start with imitation paper instruments, sitting in the orchestral positions that will be taken by the students when playing in a real orchestra. Whilst holding their "instruments," they sing songs about their musical roles in the orchestra and how they want to play the violin (Abreau et al., 2009). Beginning the violin in this way assists in developing a community aspect, which has the potential to be turned into an awareness of ensemble playing, collaboration with others and musicality. It would also seem to have the effect of inspiring the children to graduate to real instruments and start playing with music. The technical concerns of violin playing could therefore be merely seen as a tool for getting the sounds, emotions, and effects that they have already seen as necessary in the music. In effect, the method is helping the learners to create a mental model, or initiate feedforward processes of sound which then inspires the creation of the actual action.

Gary McPherson found in his longitudinal study that there was a connection between mental strategies, greater enthusiasm for learning and higher skill development, compared to those that did not use any mental strategies. Additionally, a link was found between not using any mental strategies within the first few months of learning and reduced musical skills, and even the likelihood of ceasing to learn a musical instrument altogether. These included singing the music and moving fingers in accordance with the fingering needed to play their instrument and "playing" the music in this manner from the beginning to the end, and others creating a mental image of the musical notation (McPherson, 2005). Interestingly, the mental imagery techniques used by the students followed in this research were not introduced to students in instrumental lessons, but had been learnt in the family situation – to memorise telephone numbers, for instance.

The observation about the danger of students losing enthusiasm during the early learning process had already been noted in the 19th century by violinist, composer and pedagogue, Louis Spohr (Spohr, 1832). Interestingly, observations such as his rarely seem to have inspired new approaches within the pedagogical process. Instead, pedagogues seemed to be searching for the "correct" students. L. Spohr declares that because the violin is so difficult, it should only be learnt by those who have, from nature, a "superior talent" and a "great inclination for music" (Spohr, 1832, 1). A century later Leopold Auer was still discussing the necessary "prerequisite conditions" of a student (Auer, 1921, 4). It seems that pedagogues, in identifying the type of students they thought were needed, may have inadvertently identified a problem in violin pedagogy itself: that it does not presently include an approach that can inspire or help the student to find personal relevance and discover the joy of learning. The fact that the violin student is often made to go through what pedagogues themselves have labelled the "drudgery of learning" (Doflein, 1957, 2), does indeed seem to have the effect of lowering enthusiasm for many. This is perhaps clearly represented in Susan Kempter's diagram (see Fig. 14) of "building a student" (Kempter, 2003). Whilst here she is trying to show that good posture is the basis of learning, it also effectively illustrates the usual course of violin study. The assumption at the top of the diagram that realisation of musical goals equates to personal satisfaction is correct, but significant is that this seems to be dependent upon so many variables of technique, that personal satisfaction and musical goals will perhaps also have to wait until the many facets of technique have been accomplished. It is likely this requirement may have the result of discouraging the student in the learning process, however. A student may start the learning process with the expectation of creating musical expression – in recreating and producing the range of emotions that perhaps have been already experienced though the process of listening to or singing music. This expectation can then be shattered when limitations of technique and the difficulty of its acquisition are pointed out in the pedagogical situation. A key point in violin pedagogy would seem to be therefore in keeping the interest and attention of the student throughout these stages of learning the technical components of the skill of violin playing.

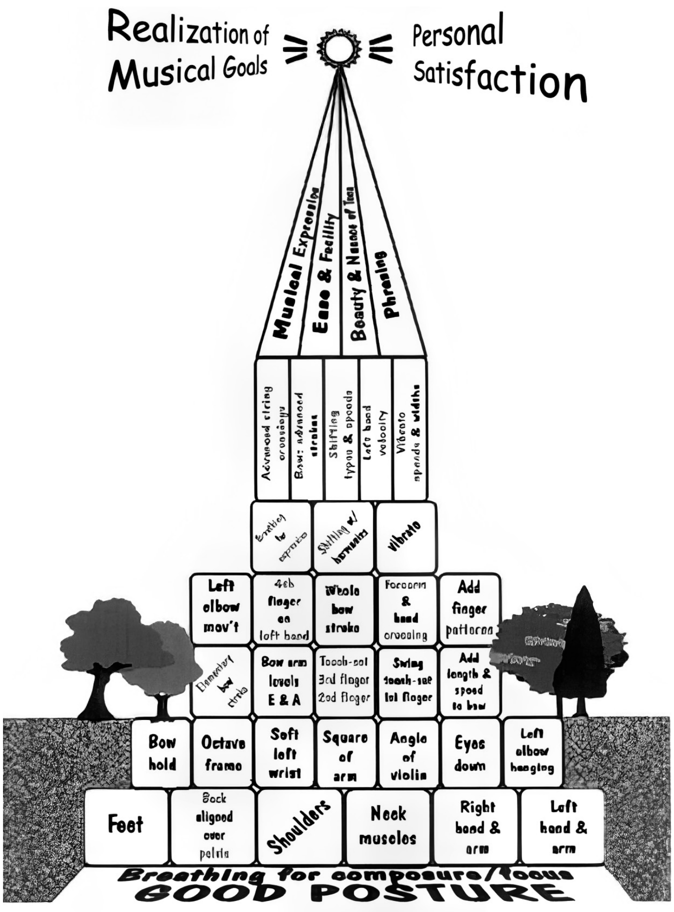


Figure 14. **"Building a student"** (Kempter, 2003, 7)

It is interesting to consider exactly why learning the violin is associated with a "struggle" or "drudgery," however. This indeed may be due to the fact that when a violin student plays a note on his/her instrument for the first time, it may not sound as the student had wanted or expected. J. Brauns remarks that in this respect, the violin is more difficult than the piano in the first lesson, considering that a note can be produced by the student on the piano that is already in tune (Brauns, 1969). Additionally, if the student has had some experience of listening to violin playing, the violins that they may have heard in recordings, or those played by their teachers, differ both physically and audibly from the violin which the young student will be playing. Firstly, the violin of the beginner – usually a quarter-sized instrument – is usually a lot smaller than that of the teacher's full-sized instrument. Secondly, the quality and set-up of the violin, the amount of rosin on the bow, the type of strings, the way they are fitted or tuned, plus the placement of the sound-post and bridge, has a great effect on the way sound is produced by the instrument. All of these elements can result in the student's instrument sounding less vibrant than any examples of violin playing previously experienced by the student. This mismatch of expectation and result can be disappointing for the young violinist. Indeed, L. Spohr recommends waiting to start the violin until the child is large enough to play a full-sized instrument (Spohr, 1832), though this is contradicted by other pedagogues who recommend starting the violin at the age of six or seven on a small-scale instrument (Targonskis & Stūresteps, 1960).

The aspect of contrast of expectation and result followed by a lowering of student enthusiasm does, however, seem to illustrate also an important point in student musical development that could be used in violin pedagogy – it shows that there is a conscious or subconscious ideal of sound and artistry that is already mentally-created by the student – similar to the non-deliberate mental model mentioned earlier – and that this could be potentially developed and used as a tool to assist the student in the violin learning process. This could be described as being the exact role of mental training: to be aware consciously of the mental model, to create it and to experiment with it. Additionally, an important part of mental training in the pedagogical process could therefore be in identifying existing models that have been created from the student's past experience and then using components from that to create a learning environment that is personally meaningful for the student. In this way, it is possible that the student may be inspired into experimentation, which in itself can develop into a motivating factor to play a musical instrument.

The vexed question of motivation. It seems that some texts discuss the role of motivation in the violin teaching and learning process with primary school-aged students. Indeed, Sinichi Suzuki explained that the most important thing in infant education is to "make the children motivated to learn" (Suzuki, 1998). Whilst this comment could be interpreted as quasi-authoritarian, it is possible, when considering the method and repertoire as a whole, to identify another level of thought behind Suzuki's statement. For instance, the set pieces that are published in ascending order of difficulty (Suzuki, 1978), seem to display a musical goal in each piece, with dynamic markings, articulations and tempo changes. They are not studies or etudes that need to be accomplished before any music-making can take place. It would seem that Suzuki's challenge of "motivation", therefore, especially in Western culture, could be rephrased as "inspiration." Indeed, the Suzuki method also promotes the importance of listening to recordings and observing others playing, that if taken out of context from the way the brain processes sound and action, could be regarded as a quasi-indoctrination of students. However, when considered together with brain research, the Suzuki method could initialise effective activation of audio-visual mirror neurons and create feedforward processes or a mental model, as mentioned earlier. Perhaps the listening aspect in the Suzuki method could be expanded to include movement and/or visualisation of personally-relevant characters and images, which may indeed help students memorise the music and add emotion and components connected to musical interpretation when playing themselves.

So, whilst it could be argued that inspiration is preferable to motivation, it seems it is also important to feel accomplishment – that success in something encourages more of the same. To understand this concept – and the meaning of "success" it is necessary to understand what occurs in the brain. What does motivation *mean* in the brain? To answer this question, it is now necessary to address how the different areas of the brain interact during learning.

Psychiatrist and brain imaging researcher, Srini Pillay, discusses "coachable" areas of the brain, areas that need to be activated during the learning process, and identifies four distinct and interconnected brain areas (Pillay, 2011). These areas are:

1) The frontal lobes and their connections

   This includes the dorsolateral prefrontal cortex, part of the outer region of the frontal lobe, the ventromedial prefrontal cortex, part of the inner region of the frontal lobe and the anterior cingulate cortex, located in the medial wall in both brain hemispheres (Stevens et al., 2011). The dorsolateral prefrontal cortex has been identified in working and short-term memory (Barbey et al., 2013) and self-control (Hare et al., 2009), whilst the ventromedial prefrontal cortex has been described as being the "accountant" – the area that assesses the benefit and risk after receiving information from other parts of the brain, including the other parts of the aforementioned frontal lobes and from emotional areas. This part of the brain has therefore been noted in its role in decision-making and memory retrieval. The anterior cingulate cortex, which detects conflict in situations has connections to both the prefrontal cortexes and the limbic system (Stevens et al., 2011).

2) The limbic brain

   This area has connections to the hippocampus – responsible for long term memory – and the amygdala – which processes emotion and attachment. Emotions get processed by the amygdala in order of significance; fear is processed first, since this is a strong emotion, but this also therefore interferes with both retrieval of information from long term memory and with assimilation of new information through resultant non-effective activation of the frontal lobes (Perry, 2006; Pillay, 2011).

3) The reward system

   This system includes the ventral striatum and within that the nucleus accumbens, which is the area of the brain that registers pleasure and reward. S. Pillay notes that this area has been associated with motivation and learning from positive feedback (Pillay, 2011).

4) The action system

   This includes the motor cortex, which is placed behind the frontal lobe and for this to be activated most efficiently all of the preceding brain processes need to be functioning optimally. More specifically, the action system receives information from the ventromedial prefrontal cortex – the brain's accountant – on whether to act or not (Pillay, 2011).

Creating brain-based mental training strategies in the violin teaching and learning process. Learning strategies and approaches need to promote activation of the short-term memory and access to long term memory, reduce activation of the limbic brain, so that the short- and long-term memory can be efficiently used and encourage positive feedback and trust in order for optimal action to take place. In a coaching situation, S. Pillay noted several "interventions" that help to encourage these brain processes to take place. Short term memory training – recalling recent events and asking the trainee to do this by asking specific time-related questions, such as those related to recent experiences they have had (Pillay, 2011). Helping to reduce conflict that could be detected by the anterior cingulate cortex can be remedied by discussing any worries and helping towards a resolution of them, rather than having a situation where potential conflict is being kept within a trainee, which could thus lead to reduced efficiency of actions and productivity. Additionally, labelling a difficult situation as a catastrophe should be avoided, since this has been associated with an increased experience of pain and chaos and therefore higher activation of the anterior cingulate cortex (Gracely et al., 2004). Breaking things down into manageable steps and therefore creating opportunities for a greater sense of self-accomplishment has been identified as helping to activate the reward system and thus inspire motivation in the trainee (Pillay, 2011). Interestingly, and relevant to the approach of administering feedback from these manageable steps, earlier research in the field of psychology has found that instant external feedback of results within the process of learning a skill was detrimental to learning and skill proficiency. A short delay before giving feedback and also allowing the student to assess his/her own skills, increased proficiency at that skill when tested two days after the initial training, despite there being no perceivable advantage of learning in this way immediately after the process was carried out (Swinnen et al., 1990). This delay of feedback presumably decreases any stress or conflict the learner may have of "belief versus reality" that may be detected by the anterior cingulate cortex and therefore allowing the frontal lobes to function more effectively, thus enabling more efficient motor activation and skill acquisition.

In the one-to-one violin teaching situation several opportunities can be identified for inclusion of brain-based strategies and effective introduction of mental training techniques. The lesson could begin, for instance, with the teacher asking the student about events or lessons that have happened earlier in the day, thus "warming-up" or activating short-term memory circuitry – a requirement for optimal assimilation of any new information that may be gained in the lesson. Additionally, a discussion between the student and teacher about what was achieved in the previous lesson and what will be played in the present lesson can both potentially help the student self-evaluate previous achievements, thus activating the reward centre circuitry and therefore diminishing any stress that may otherwise have interfered with future learning in the current lesson. Recalling previous playing can help the student build on what has been achieved before and also help to activate the long term memory, which is potentially needed in memory recall of a musical work. It may also help later in the lesson to activate the reward centre if a comparison can be drawn between the current day's playing and the playing from the previous lesson. It should perhaps be noted, however, that if the teacher perceives a diminishing of standards from the previous lesson, this comparison should probably be played down to the student. Instead, manageable tasks could be devised that could help remedy the situation (Pillay, 2011). In fact, with reference to the research in neuroscience, it is indeed possible that a diminution of standards may not be due to the student not practising individually, but due to the student practising incorrect skills a great deal, since practising skills – even the incorrect ones – makes those the synaptic connections for those skills stronger (Willis, 2006). Indeed, judging a performance negatively compared to a previous achievement could activate the limbic system and the anterior cingulate cortex – the conflict monitor – resulting in reduced learning and also reduced physical action. After recalling previous achievements and agreeing on the content of the lesson, the student can commence playing whilst the teacher takes note of the skills or musicianship that needs to be addressed and considers the positive language that can be used to convey these observations. Again, breaking down the components of the skills needed to be improved into manageable "chunks" that the student can easily understand, helps to motivate the student into doing the action. When breaking down the skills to be worked upon in this way, it is possible to clearly identify when the "traditional" components of mental training can be applied – such as demonstration/observation, progressive relaxation, mental rehearsal – and other, less "traditional" ones, such as metaphors, humour, etc. Indeed, since mental training by its very definition also involves "the psychological and cognitive elements which influence the learning and performing of a task" (Mayer & Hermann, 2011, 8), it seems clear that the brain-based strategies identified from the research in neuroscience are at the very heart of mental training. Thus, with the use of these strategies and approaches, mental training in the pedagogical process starts from the very beginning of the violin lesson, from the verbal "warm-up" designed to activate the short-term memory.

Of course, any amount of variation can apply to the suggested lesson structure above. For instance, entirely independent playing by the student may not occur – especially if the musical work is completely new to the student in that lesson. In this case the teacher needs to assess what approach to take – whether demonstration is necessary, or whether the student needs help with initial fingering or bowing, depending on the individual needs or indeed, age of the student. But the principles discussed earlier in this paper are still relevant: positive language, small manageable steps, fun approaches, demonstration, relaxation, mental imagery and metaphors, mental components alternated with physical components. An additional component to the structure of the violin lesson could also be added: that of the resolution of any perceived internal or external conflicts of beliefs or preferences by the student. These could include, but are not limited to, a student belief that a task is too difficult for them, which in turn could lead to a negative mental image of that task, leading to an increase in anxiety. Preferably, these need to be detected by the teacher and talked about in the lesson situation if the brain's accountant – the anterior cingulate cortex – is considered and a non-stressful creative atmosphere is to be maintained.

Thus, a structure for procedural incorporation of mental training in the one-to-one violin teaching can be proposed (see Table 3). Each organisational phase in the model has connected: content, teacher / student activities and brain-based connections. The lesson plan is devised to maximise the creative process: the collaborative process of planning goals, devising and planning processes and manageable steps to achieve them and using individually-based and personally significant metaphors within the process help to provide this creative environment.

Table 3. **Envisaged structure of the individual lesson with mental training**

Brain-based connections	Organisational phases of lesson	Content	Teacher/student activities	
			Teacher	Student
Activation of frontal lobes, short-term memory activation, mirror neuron activation (attitude/ emotion), possible reduction of limbic system involvement	Preparation for learning	Verbal "warm-up"	Conversation about that particular day's events Positive attitude, encourages the same in the student	Tells about the day's events, or some funny or interesting recent event Positive attitude
Activation of the reward system, preparation of the action system and motor cortex, spontaneous mental imagery is created of past and future actions	Goal identification and goal setting, recollection of previous achievements	Teacher-student planning of content	Recalls what was achieved in previous lesson Specific discussion about what is going to be played and worked on in the lesson, including the specific goals for that lesson	Recalls achievements attained in previous lesson Action and skill planning

Brain-based connections	Organisational phases of lesson	Content	Teacher/student activities	
			Teacher	Student
Activation of mirror neurons (during observation), positive mental imagery and reward system activation (positive teacher language; identification of manageable steps)	Practical realisation of playing	Playing of a musical work by student or demonstration by teacher	Non-verbal assessment of student skills / accurate demonstration of violin playing Consideration and positive use of language to communicate and discuss with the student about what needs to be worked upon Planning how to delineate the skills that need to be improved into manageable "steps" that can then be identified positively by the teacher and student Use of language and imagery that illustrates positive outcomes of playing standards and learning process	Playing of a musical work / observation Positive attitude towards working to improve skills Constructive self-assessment of playing
Mirror neuron activation, reduction of limbic system activation, activation of sensory cortex and motor cortex	Introduction of "traditional" mental training components	Use of specific mental training components for skill development	Realisation of the manageable "steps;" encouragement of mental imagery, demonstration and observation, metaphors, relaxation, mental rehearsal, continued use of positive language	Use of varied mental training techniques to work on the specifics of violin playing, musical interpretation, etc., that can be later used independently
Combination of physical and mental processes	Practical realisation of playing	Repeated playing of sections of the musical work	Teacher encourages the use of combined mental and physical components during the process of playing	Use by the student of combined mental and physical components

Brain-based connections	Organisational phases of lesson	Content	Teacher/student activities	
			Teacher	Student
Reduction of any conflict detected by the anterior cingulate cortex and reduction of limbic system activation	Internal conflict reduction	Resolution of any perceived internal or external conflicts of beliefs or preferences by the student which may have occurred due to student misunderstanding technical or musical tasks or student using negative imagery / internal dialogue	Identification of any "conflict" areas and to help the student resolve these	Expression of any mismatch between expectations and result
Activation of the reward system	Assessment	Summary of the lesson for that day and student self-assessment	Summary of what has been achieved Encouragement of student comparison of goals set, those achieved and those that need to be worked on Discussion about processes used and future work to be carried out	Assessment of achievements in both the process of learning and of the results Comparison of the goals set at the beginning of the lesson and achievements attained Summarisation of processes used to attain results and how to carry out future work to be carried out

Since it can now be seen that applying small steps and helping the students to be aware of their achievements can help to gain from the interaction of structures within the brain, it now remains to describe the specific skills connected to violin playing that are actual in the teaching and learning process of primary school-aged violinists.

The techniques involved in the skill of violin playing. Most method books give an outline of the various technical and music theory elements that need to be learned by the student within the first few years of study. These include the very basics of posture and technique. Interestingly, the basics of posture are still discussed in methods for more advanced students (e. g. Galamian, 1962), suggesting perhaps that these components could indeed be acquired more effectively at the beginning of studies.

The components in the following list by J. Targonskis and V. Stūresteps, clearly illustrate the focus of techniques in the first few years of violin study:

- The basics of music theory.
- The pose of the violinist. Holding the violin and bow.
- Correct tone production.
- Development of the feeling of rhythm.
- Left hand finger movement: falling, sliding and sideways movements.
- Development of a musical ear. Correct intonation.
- Elementary bowing. Movements of the right arm which are steady and irregular.
- Dynamics. Pressure of the bow on the string, bow speed and volume of the sound. Accents.
- Tempo and character in performance of works. Musical phrasing.
- String crossing.
- Double stopping and chords.
- Development of agility.
- The fundamentals of playing in an ensemble.

(Targonskis & Stūresteps, 1960)

The Basics of Musical Theory. In their method book J. Targonskis and V. Stūresteps follow a learning approach taken by many authors, since the days of L. Spohr and could therefore be described as being "traditional" in its approach. Method books of this kind introduce how the violin should be chosen and kept, use of the shoulder rest and chin rest, naming the different parts of the violin and bow, stance and posture. Similar to many of the more modern methods, J. Targonskis and V. Stūresteps include photo representations of playing posture and of how to hold the violin and bow. This is followed by a general introduction to music theory and some tasks for the students to complete on paper. The value of notes and rests is also outlined, together with time signatures and musical terms. Actual playing starts in the third chapter on page 28 with the student reading the musical notation and using the bow on open strings. It is interesting to note that methods such as this require the student to complete the initial tasks away from the instrument. Exactly how strictly teachers follow the practice of beginning with a long introduction of theory is not clear, but presumably the musical theory and playing can be introduced in a parallel manner, though this is not made clear in the method itself. Later violin method books, such as the *Doflein Method*, include shorter introductions, and playing without musical notation begins on page 7 (Doflein, 1957). This method includes a visual representation of the placement of the fingers and all of the fingers of the left hand are used on page 8 (see Fig. 15).

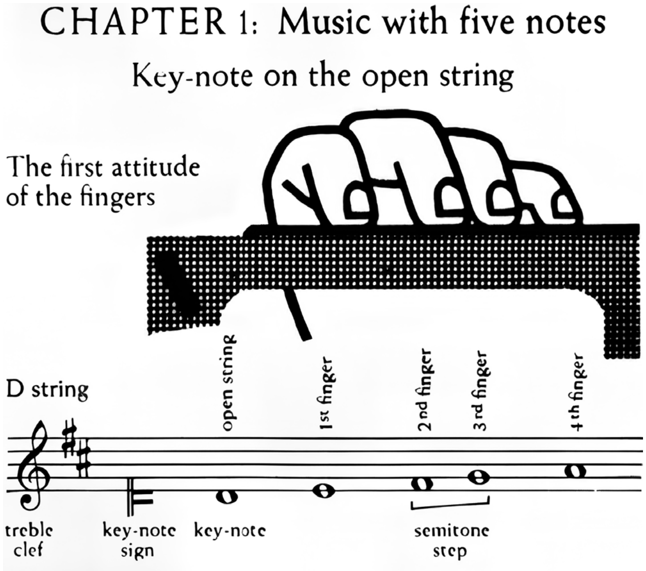


Figure 15. **Finger Placements** (Doflein, 1957, 7)

Later method books incorporate music theory gradually together with the practical playing exercises (e.g., Davey, 2002).

Whilst it is not necessary to repeat here what is written in many method books about the holding of the violin and bow, a few important features of basic technique which are often overlooked in novice method books should be drawn attention to.

Posture. This would seem to be an important aspect of technique, seeing as it sets the foundation for all other aspects of violin technique. For many of the older books, posture is dealt with in the opening chapters. However, very few books deal specifically with the placement of the feet. This is noted by J. Brauns, who emphasises the importance of the placement of the feet (see Fig. 16) in giving the correct distribution of balance of the body. He warns that incorrect distribution of balance can disturb the movement of the hands (Brauns, 1969). This, then, would seem to be an important aspect of technique that should also be paid attention to with primary school-aged students.

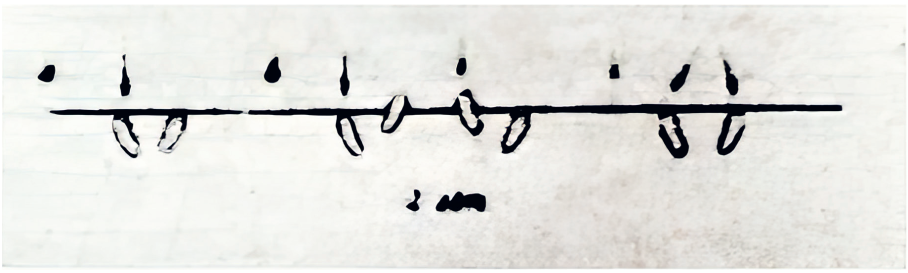


Figure 16. **Foot placement according to J. Brauns** (Brauns, 1969, 41)

Holding the violin and bow is often shown visually in images or drawings. J. Targonskis and V. Stūresteps note that the edge of the violin needs to be placed on the collar bone (Targonskis & Stūresteps, 1960), and on the left shoulder (see Fig. 17). Very few books note that once the violin is placed on the collar bone, the shoulder rest should fill in the gap between the violin and the shoulder. Some method books suggest raising the left shoulder (Seidel, 2008), though as specialists in the Alexander Technique have pointed out, this can cause unnecessary shoulder tension (Armstrong, 2015). It would therefore seem to be important to check that the shoulder rest set-up for the child is checked frequently.

Figure 17. **Holding the violin** (Seidel, 2008, 1)

When holding the violin bow, it is important to make sure that the student's thumb is bent underneath the bow, the little finger is on top and the first finger is slightly extended along the bow stick. The whole lower arm is also slightly turned clockwise, so the palm of the hand is facing away from the body (see Fig. 18). This facilitates better transference of weight from the arm and hand into the bow. A straight thumb causes counter pressure to the arm and hand, thus causing tension in the hand and prevents the player from playing *into the string,* the absence of which creates a thin, unfocussed sound.

Figure 18. **Bow Hold** (Seidel, 2008, 2)

Other elements of technique that need to be clear for students in this age group include the bow speeds and division of the bow when playing multiple notes per bow, plus the knowledge about how to produce different gradients of dynamics. Simon Fischer clearly outlines the different sound points on the string and how they affect dynamics and tone production. Whilst this is not included in many methods for beginners, a concept of this is considered important in violin playing and does not have to be limited to advanced players (see Fig. 19).

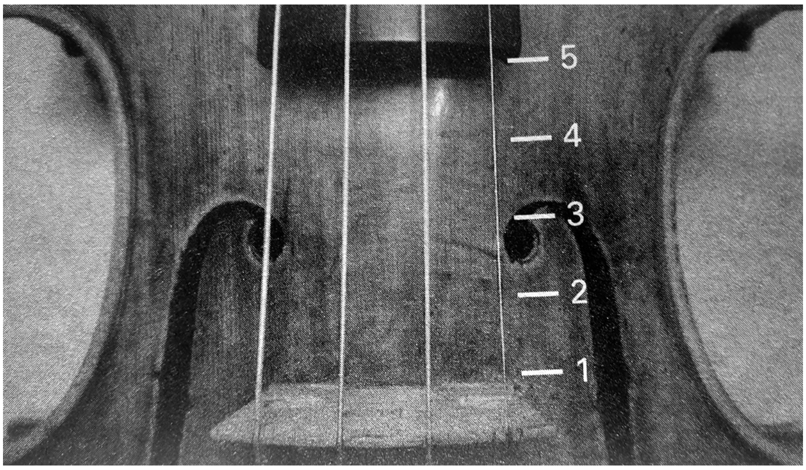


Figure 19. **The five sound points in first position** (Fischer, 1997, 41)

Before moving on to the next chapter about the developmental suitability of including mental training into the violin teaching and learning process of primary school-aged violinists, it is necessary to outline the parameters of intonation – which, as J. Targonskis and V. Stūresteps affirm, is important to develop in the early stages of learning. It does seem to indeed be a component that many violin teachers concentrate on in lessons, yet one which is very rarely described in method books. That the violinist's intonation differs from the equal temperament on the piano, for instance, is little documented, but one which is referred to, at least orally, at conservatoire level. Whilst a thorough history and knowledge of the physics behind violin intonation is perhaps not necessary for the primary school-aged student, teachers, and indeed players, should be aware of the principles, so that they have an informed mental model upon which to base explanations and demonstrations in lessons.

Pitch and intonation. Intonation in string playing, the slight variation in pitch that can be adjusted by a player (Salzberg, 1980), is a challenge that faces string players life-long (Brooks, 2007). As one author says, it is a subject upon which novice learners tend to spend a considerable amount of time, and a challenge sometimes considered so daunting that it may even be the catalyst for learners giving up the instrument (Kanno, 2003). Various publications have reported the observation of string teachers and researchers that good intonation is first generated within the player's head (e. g. Martin, 2004; Bergonzi, 1997), yet the actual mental aspect of this challenge – training so that this mental aspect becomes clear – is not addressed in many methods taught practically.

Indeed, Louis Bergonzi himself, whilst at the same time acknowledging the importance of the mental aspect of intonation, advocates the use of finger placement markers – areas drawn or stuck to the fingerboard of the violin to visually show players where to put their fingers. Whilst his study reported an improvement of intonation using this method, it could be argued that the finger placement markers create an extra information that needs to be processed as visual perception – which becomes an additional load to the visual perception already required when reading musical notation. It therefore could be argued that it acts as a distraction, rather than an aid, to creating the necessary mental model of sound. In fact, even when playing from memory, the necessity to visually perceive the finger placement markers and adjust motoric movements to them, rather than to the mental model of sound, would seem to encourage a skill that will not be useful or required in later learning. In fact, it creates a dependence on the finger placement markers. Prolonged use of finger placement markers has the danger of distracting from the sound-movement connection; that prolonged use may increase a dependence that can become inhibitive in normal musical situations if the finger placement markers are removed. By comparison, the method books that show diagrams of finger placements, such as in E. Doflein's publication mentioned earlier, which create an awareness of the necessary varying distances between the fingers, could help to provide a mental concept of finger placements, since it does not require simultaneous visual perception and motoric adjustment. Yet, it would seem to be the internal creation of sound that is most important in the learning of intonation.

But how can this internal sound be trained and connected to the movements and techniques required in violin playing? Can simply asking a student to concentrate harder on their intonation, therefore, really help them to improve it?

Interestingly, it would seem that the direct teaching of intonation – that is, asking students to pay more attention to their generation of pitch, often creates the opposite effect: intonation becomes more difficult for the students. This difficulty has been noted by E. E. Gordon, who noted: "I found that tone quality is much more important than intonation. If I get them (students) to think about quality, I get an improvement in intonation. But if I talk about intonation and not quality, it's a tough up-hill battle" (GIMLPublications, 2011, 5'08").

Putting this concept together with Christopher Brooks' observations – that a player needs to have a comfortable physical relationship with the instrument in order to realise a player's "sense" of intonation – and the theories from psychology and neuroscience about situations that are deemed as uncontrollable causing stress – in this case, the perceived teacher evaluation of intonation – it could be posited that specifically concentrating on intonation creates muscle tensions which make it more difficult for students to realise their aurally-imaged pitches. This in turn may prompt a teacher to conclude that a student's aural abilities are flawed, a judgement that potentially causes more uncertainty for the student and therefore adds to any already-existent stress, which in turn further impairs the realisation of good intonation.

At present there seems to be a lack of violin-specific methods that help with the approach and understanding of developing student intonation. Since it can be seen that intonation is dependent on mental models, it would certainly seem to be something that could be addressed with mental training, or perhaps by adapting mental training methods to be relevant in the collaborative pedagogical process. But since it is now clear that a clear and accurate mental model of intonation needs to be built, it is important at the start of this process for the teacher to understand the foundations of *good* or *desirable* intonation in violin playing.

Interestingly, authors have noted that perfect intonation is mathematically impossible (see Brooks, 2007), that professional violinists often mix two types of tuning systems in performance (Sassmannshaus, 2012a):

1) Harmonic, also called "Just" intonation – used mostly in the playing of thirds and sixths as double stops and in chordal passages in string quartet playing (Sassmannshaus, 2012b);
2) Sequential, also called melodic or Pythagorean intonation – used more frequently by violinists than harmonic intonation, especially in solo playing. It is characterised by narrow semitones and large whole tones. This is most noticeable on major and minor thirds and on leading notes (Sassmannshaus, 2012c). Studies have also noticed that according to this system, players often raise intonation when playing an ascending melody and lower it when playing a descending melody and additionally, that the use of accidentals in musical notation of diatonic music is connected to this system of tuning (see Kanno, 2003).

Another type of intonation relevant to the present study has been identified as "corrective" tuning – where a player perceives an adjustment to a note needs to be made, such as in string quartet playing when a chord should be played using "just" intonation (see Kanno, 2003). Interestingly, violinists rarely intonate to the equal temperament of the piano, except when playing in unison with it (Sassmannshaus, 2012a).

The teaching and learning process needs to be clear, focused, interesting and inspiring for students. The concept of difficulty need not enter into the teaching arena. Indeed, there has been a tendency for violin methods books written in the last twenty years, such as those by Peter Davey (Davey, 2002), to include the basics of "advanced" techniques, such as left hand pizzicato, much sooner than in earlier violin method books. This development could be considered as positive, since it effectively mentally prepares and helps the student for future repertoire. If musical violin playing does indeed depend on so many technical variables, then these techniques should be introduced much earlier to students. Lessons should be designed so that the student can achieve the musical goals and personal satisfaction that S. Kempter referred to at any age and stage of learning. The contrast noted between student expectation and result reveals the potential that learners have for mental training. This can be developed and used as a catalyst for becoming a great violinist.

In analysing the literature in neuroscience (Schwenkreis et al., 2007; Bangert, Schlaug, 2006; Classen et al., 1998; Zatorre et al., 2007; Ellis et al., 2012; Zatorre et al., 2007; Ellis et al., 2012; Palomar-Garcia et al., 2016; Chen et al., 2008; Kajihara et al., 2013; Gracely et al., 2004; Barbey et al., 2013; Stevens et al., 2011), psychiatry (Pillay, 2011; Stevens et al., 2011; Hare, 2009), psychology (Swinnen et al., 1990) sports psychology (Makenzie, 2001; Frank et al., 2016) Music psychology Gruhn, 2015), musicology (Brooks, 2007; Salzberg, 1980; Kanno, 2003; Martin, 2004;) music pedagogy (Fischer, 2013; Brauns, 1969; Abreau et al., 2009; Spohr, 1832; Dolfein, 1957; Targonskis, Sturesteps, 1960; Suzuki, 1998; Galamian, 1962; Seidel, 2008; Armstrong, 2015; Bergonzi, 1997; Sassmannshaus, 2012), it is possible to conclude that:

- The feedforward and feedback processes in the brain employed when playing an instrument are very similar to the imagery processes employed in mental training, with the difference that mental training encourages a conscious and deliberate awareness of these processes;
- There is no necessity to wait to include musical components in the pedagogical process. Creating musical interpretations in a personally-relevant manner can become goals and an inspiration to explore the components of violin technique;
- The application of mental training is little researched in the violin literature and there does not seem to be any current literature that discusses the systematic use of mental training to develop the skills of violin playing;
- Mental training encourages the personalisation of the learning process;
- The importance of the collaboration between teacher and student for developing violin skills is often neglected in the violin literature, but can be encouraged with the use of mental training in the pedagogical process;
- Though much of the violin learning process is based on creating a good sound with perfect intonation and accurate rhythm, exercises to assist in creating this in a collaborative manner seem to be non-existent in the current literature;
- Methods to assist in creating dynamic range and musical interpretation are also rare in the literature, which for novice violinists usually concentrates on pure, and also not personally-relevant, acquisition of violin technique;
- Mental training components, inspired and backed up by research in neuroscience and pedagogy, can be organised into the collaborative pedagogical process;
- Mental training in the pedagogical process should include organising the learning material into include small, attainable steps, so that each step can be identified by the student as an achievement, thus activating reward systems in the brain;
- The concept of inspiration in the pedagogical process is often neglected, but one which helps create student mental models, which can assist in student enthusiasm for learning.

1.4. The Suitability of Mental Training for Primary School Students in the Improvement of the Skill of Violin Playing

The fact that primary school-aged children are able to represent the world through mental images has been noted by Jean Piaget (Piaget, 1973). At the ages of 6 to 7, students in their first year at primary school border the second and third stages of J. Piaget's four stages of cognitive development. In the second stage – the "preoperational stage" of ages two to seven – J. Piaget noted that children gain the ability of mental imagery with the acquisition of language. At this stage symbols and images are dependent on a child's own egocentric perception and intuition. Also, they may be able to count to ten, but not understand that a number, such as "one" symbolises one object only. This may be significant when considering the learning process of first- and second-year violin students, who need to be aware that the note they see on the page has an associated sound. The third stage – the stage of "concrete operations" of ages seven to eleven – begins when the child is able to carry out mental operations. A "mental operation" as defined by J. Piaget is an action performed in the mind. With this ability, he notes that children can internally visualise an action that has been previously performed. Symbols, such as numbers, now represent the corresponding number of objects. A child in this stage can apparently also reverse the direction of thought – if something can be added it can be subtracted, visualising the whereabouts of a lost object is also possible, rather than randomly searching for it in various locations.

These observations are significant in the area of mental training, as it shows that the child in the primary school age group has the ability to create working mental images. J. Piaget's observation that the images can be recreations of actions already carried out by the child, links up with the research that mental images are stored in long term memory (Hishitani 1993). Additionally, the ability to realise that symbols can represent a further concept shows that they have the ability to read music and understand that each note can represent a sound.

Before discussing the changes in the brain that occur during the development of a child, it is interesting to note the differences between theories of cognitive development that were proposed by J. Piaget and L. Vygotsky. Whilst this comparison has been made before in many publications, it is necessary to broadly mention their differences here, so that the concepts can be related to current research in the field of neuroscience and also to the few existent methods that use the components of mental training in sport for children.

Piaget's concept of development posited that cognitive development is universal, whereas Vygotsky proposed that the surrounding culture and society also affect this. Piaget noted that a child's independent exploration of the world resulted in cognitive development and that the child constructs knowledge herself, whereas Vygotsky with his theory of the zone of proximal development noted that cognitive development was also the result of social interaction and guided by more knowledgeable others – peers or adults, for instance – who together construct knowledge and pass on their particular culture (McLeod, 2014). Interestingly for this study, Vygotsky, in his *Mind in Society*, discusses the relationship between the more knowledgeable, or more capable other and the student: that he or she becomes a model of behaviour for the student; that this more knowledgeable person may also issue verbal instructions and that both behaviour and verbal instructions create a collaborative environment that becomes internalised by the student, who uses it to govern or regulate his own performance (Vygotsky, 1978). This closely links to the concept that J. T. Gallwey noted in his book on mental training in sports – where the teacher's words become the internal voice of the student's (Gallwey, 1974). Additionally, A. Bandura's work also mentions the way that modelling and imitation can occur in this way (Bandura, 1977). Piaget, on the other hand argued that language derived from the child herself and after this becomes more social.

One of the greatest differences between J. Piaget and Vygotsky would seem to be that Piaget proposed that development precedes learning and Vygotsky, that learning precedes development. Although many secondary sources report that this is the point upon which Piaget and Vygotsky rigidly disagree, L. Vygotsky himself stated:

"Development in children never follows school learning the way a shadow follows the object that casts it. In actuality, there are highly complex dynamic relations between developmental and learning processes that cannot be encompassed by an unchanging hypothetical formulation" (Vygotsky, 1978, 85).

Indeed, when comparing the combined differences of J. Piaget and L. Vygotsky with neuroscientific research, it would seem that both theories are valuable in the pedagogical process. It also seems that both theories fairly accurately tie up with the research connected to the concepts of mental training. The fact that internal representations and language originate from the inner world of a child and move towards the external, can be seen in the formation of mental imagery and how it dictates future actions. This has particularly been displayed in the research that noted the difference between the use of positive and negative imagery and its influence on performance mentioned earlier. Additionally, that this inner imagery is at first created from knowledge and experience gained by an individual from the outside world has also been corroborated in neuroscientific research; that mental imagery is first accessed and produced from experience stored in the long-term memory.

But how much does neural development affect the course of learning? We know that learning affects and increases synaptic connections within the brain – this has been stated in earlier chapters, and perhaps corroborates L. Vygotsky's notion that learning precedes development. But what is known about the development of the brain itself and the neuronal circuitry during this process?

Interestingly, P. Wolfe notes the importance of myelination in brain development. Myelin, a glial cell that wraps around neuronal axons, allows faster transmission and synchronisation of impulses, but this process happens at different rates, starting with cells that determine survival function and moves towards those in the prefrontal cortex in adolescence, increasing abilities of abstract thinking (Wolfe, 2010). Since myelination also occurs through repeating a skill or learning (de Faria et al., 2021), it could be argued that it is truly a combination of both physical brain development and exposure to learning that assists in learning processes.

Indeed, studies in neuroscience have identified that brain regions that regulate attention, reward and goal-oriented behaviour, inhibition do go through development and re-organisation during later childhood and early adulthood; that the frontal cortex begins to take on an increasing regulatory function and that these changes do indeed contribute to the increasing range of cognitive behaviour in later childhood and adolescence (Yurgelun-Todd, 2007). It would seem then, that children acquire an increasing ability to use mental processes, but that mental imagery – a main component of mental training – is employed from an early age and therefore viable in the pedagogical process. Indeed, as mentioned earlier independent use of mental training-type components by novice primary school-aged students, such as imagery and mental rehearsal, has been noted in music pedagogy (McPherson, 2005). Additionally, use of mental imagery has been identified in children of less than a year old when accomplishing challenging tasks (Heyes et al., 2013; Keen, 2011).

Considering that mental imagery is employed already in the younger developmental stages, and that it is likely based on concrete experience, it is perhaps not surprising that children from about the age of 11 – the stage of "formal operations" described by J. Piaget – demonstrate the capacity for abstract thinking, hypothetical reasoning, and systematic problem-solving; that they can manipulate and plan ideas in their heads, without resorting to tangible experiences (Inhelder & Piaget, 1958). This is significant for this study, since some of the older students in this study border on this developmental stage. It is interesting, however, that "traditional" mental training exercises – those which are used by already-trained practitioners – often involve alternation of mental and physical practice. Thus, a tangible component is evident.

These observations highlight aspects not frequently discussed in the mental training literature. Firstly, that alternating mental and physical practice plausibly facilitates further use of pure mental practice. Secondly, that it is possible that exercises based on mental practice, the manipulation of mental imagery in alternation with physical practice transcend traditional notions of developmental stages.

Whilst this aspect has not been widely discussed in the literature, there have been very few studies researching the potential of mental training for children. The few studies that exist have been in the area of sport (Orlick & McCaffrey, 1991; Julien, 2002; Li-Wei et al., 1992). The authors of these studies have noted that the skills should be used in other areas of children's studies. Terry Orlick and Nadeane McCaffrey have also found applications in helping children overcome serious illnesses (Orlick & McCaffrey, 1991). One study reported how mental imagery in reading improves 8 year-old children's memory of what they were reading (Pressley, 1976). There seems to be little, if any, specific research on child mental training methods in music. Additionally, the literature that exists on child mental training methods in sport was mainly written two to four decades ago – and this literature is still being quoted in more contemporary sources. The exact same imagery noted in the study in 1991 (Orlick & McCaffrey, 1991) is still being used in reports fifteen years later (e. g. Gould, 2006). On the one hand this is a good sign – it proves that the methods work. On the other hand, it indicates that there is a dearth of contemporary research. This may be due to the fact noted by T. Orlick and N. McCaffrey, that the mental training techniques used with high performance athletes also work well with children. Importantly, however, they note that the exercises need to be adapted, explained and simplified to work effectively.

But how can mental training exercises be tailored for the child? To understand this, it is necessary to look at the elements of mental training used with adults and older students. As noted earlier, many mental training exercises involve relaxation, which acts as a stress reliever and also helps to attain a calmer mind set necessary for effective learning. Also noted in the literature is the fact that this relaxation often induces the slower brainwave frequencies of alpha of approximately 8–13 Hz and that fluctuation into alpha can enhance learning and cognition (Palva & Palva, 2007; Li et al., 2023). It is interesting to note that the alpha brainwave rhythm is normal in children who are awake and in adults who are in light sleep with their eyes closed. Perhaps then, meditation or relaxation techniques may not have the same effect with children, as they do with adults. Again, this aspect does not seem to have been researched. Nevertheless, T. Orlick and N. McCaffrey note that children do get stressed, and mental training can be an effective way of managing this and also is important in setting the correct habits for later life and for setting the belief that any goal is attainable (Orlick & McCaffrey, 1991). In their article, T. Orlick and N. McCaffrey have adapted a progressive relaxation technique. It is interesting to note that to make it more accessible for children, abstract visualisation is employed. Since it is known that, according to Piaget, children in the primary school age group clearly have this ability, this is evidently an effective way of adapting the relaxation method.

The relaxation method used by T. Orlick and N. McCaffrey starts by getting the children to move their toes at alternating speeds (e. g. slow-fast-slow). This is done to show how they are in control of their own movements. Then the difference between tense muscles and relaxed muscles is illustrated with a piece of spaghetti that is raw versus a piece of spaghetti that is cooked. They illustrate when spaghetti is raw it is like a tense muscle, and it can snap. The children are encouraged to take a piece of raw spaghetti in their hands and feel how easily it can snap. They are asked to then compare this to their knowledge of what cooked spaghetti is like: which is warm and soft and curls up on a plate. The children are then asked to make their toes feel warm and soft like cooked spaghetti. Then they are told that when people are worried or scared or if something hurts, muscles become hard and stiff, like uncooked spaghetti, but that people feel a lot better if, when they are worried or scared, they have muscles that are like soft, warm spaghetti lying on a plate. The children are then told that it can help if they make their hands and toes go like soft spaghetti on a plate. This idea is then extended to the mouth and tongue, eyebrows, and the children are then introduced to the idea that they are able to make the whole body soft and sleepy (Orlick & McCaffrey, 1991). It is interesting that the visualisation of spaghetti, in its two different states, effectively becomes a symbol for the children of the ability to change psychological states. Further, their experience of holding and snapping the spaghetti in their hands, presumably deepens their experience involves multiple sense modes and association that can assist them in the learning process and with memory (see Willis, 2006). Additionally, the symbol of spaghetti can be used later as a keyword in training to represent relaxation. The idea of developing keywords and reminders referencing the mental skills they have practised is supported by T. Orlick and N. McCaffrey. These they say can also be in the form of verbal reminders, stickers, signs, a piece of tape of the wrist or finger or a keyword written on the shoe. T. Orlick and N. McCaffrey note the improvement of mental skills with practising them and therefore recommend integration of them in daily practice routines (Orlick & McCaffrey, 1991). One study of table tennis students aged 7–10 found that the duration of relaxation exercises commenced at the beginning of mental training sessions could be reduced from 20 minutes to 5 minutes after just two weeks of relaxation training of three times per week (Li-Wei et al., 1992).

W. T. Gallwey spent a large proportion of his work researching the most effective styles and approaches for teachers (Gallwey, 1974). T. Orlick and N. McCaffrey also noticed the effect of presentation, teaching styles and attitudes with children. They noticed that children need to know that the teacher cares before they care to listen to the information the teacher wants to give the child. They point out that they need special treatment – to be listened to, to be interacted with, to use their input and notice their qualities and strengths, which aligns with research in neuroscience, showing the advantages of "warming up" frontal lobe brain areas, responsible for the registering of new information before learning, by asking learners questions about their experiences earlier in the day, for instance (Pillay, 2011) and with concepts within humanistic pedagogy.

Also T. Orlick and N. McCaffrey note that reminding children of their strengths and positive capacities has good results (Orlick & McCaffrey, 1991). This is perhaps in contrast to T. Gallwey's research with adults, where complimenting amounted to a form of judgement and did not obtain good results (Gallwey, 1974). Other research too, would suggest the situation may differ in the case of children. Katherine J. Sullivan, Shailesh S. Kantak and Patricia A. Burtner found that children learnt a motor task more accurately when they received 100 percent feedback from their actions – in this case, from a computer – whereas adults performed better when they had no feedback from their actions. In their study they also found that children who received reduced feedback of 62 per cent can catch up to the level of children who had feedback after being given feedback for a short time (Sullivan et al., 2008). T. Orlick and N. McCaffrey also note in addition to reminding children of their strengths, playing down negatives also helps. Methods recommended for doing this include helping the students to remember when they performed well, or good things about their performance. This also aligns with research in neuroscience, where increased volume of posterior insular grey matter, responsible for emotional processing and self-awareness, is noted after frequent parental praise (Matsudaira et al., 2016).

Another aspect perhaps missing in research with adults is the element of "fun." T. Orlick and N. McCaffrey suggest this element is maintained in exercises to maintain interest. They suggest in the relaxation exercise, for example, that children can have fun pretending that they are a warm piece of spaghetti curled up on a plate. This also seems to be a useful exercise, as it effectively practises internal imagery.

The fact that visualisation in child mental training seems to enable many techniques that can be used more dryly in adult mental training methods is illustrated by T. Orlick and N. McCaffrey's technique of diverting the focus away from worry. They suggest doing this by having the child put the worry in a tree or a matchbox or putting the stress in a bag. This technique is labelled by them as a "concrete, physical component" (Orlick & McCaffrey, 1991, 331).

Other elements pointed out by T. Orlick and N. McCaffrey include an "individualised approach" whereby exercises can be adapted to fit in with the interests of the child. For example, a relaxation exercise that involves floating on a cloud may be more interesting than spaghetti for some children. Being flexible as a teacher and being aware that multiple approaches can be used if one approach does not seem so successful. Being positive and hopeful as a teacher – projecting your belief that the child can achieve his/her goals and overcome any obstacles that get in the way. Using role models is seen as another important technique – this can be achieved by watching videos of athletes to see their skills and techniques. Involving parents is also seen as important in the mental training process. As T. Orlick and N. McCaffrey explain, parents can help by reinforcing the positive concepts and approaches being taught. Many of the points T. Orlick and N. McCaffrey make are similar to techniques that can be found in adult mental training methods (see Fig. 20). The "individualised approach" is similar to W. T. Gallwey's idea that the teacher needs to follow the interests of the student being taught (Gallwey, 1974) and the method of student observation has already been outlined in connection with adult mental training methods and scientific research on mirror neurons and imitation learning.

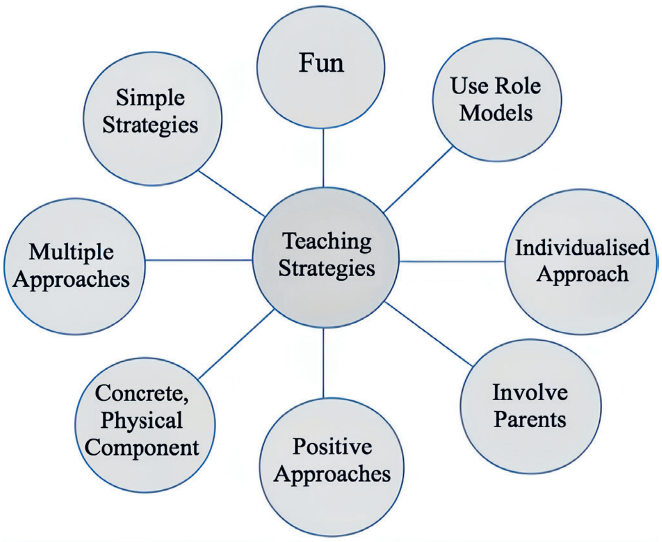


Figure 20. **Mental strategies for children** (diagram based on the concepts of Orlick & McCaffrey, 1991)

Not clearly outlined in T. Orlick and N. McCaffrey's study are the techniques children can use in the actual mental rehearsal of a task. They are concerned more on the psychological aspect of setting and realising goals. Whilst this is an important aspect, reference to other sources needs to be made for the mental rehearsal aspect. This aspect is reviewed in a study carried out on seven- to ten-year-old students in China, by Zhang Li-Wei et al., and studied the progress of children using mental training versus those who did not (Li-Wei et al., 1992). In this study, the mental rehearsal aspect was carried out after video observation. The children were asked to imagine themselves carrying out the actions "in their mind and body" just as they had seen in the video. It is interesting to note, however, that this element was not introduced at the beginning of their mental training programme. The mental rehearsal aspect was only introduced in the 4th week of a 22-week course. Since the ordering of mental training techniques is significant in many methods used with adults, it will be useful here to document the order used in research with children:

- Week 1: the children were introduced to the idea of mental training. Here, the children were told about the value and techniques of mental training in simple terms with the idea that it would help them focus and believe in the programme's value. These sessions were held three times each for 30 minutes.
- Weeks 2 and 3: basic relaxation skills, which focussed on breathing and progressive relaxation. These sessions lasted 20 minutes and were repeated 3 times per week.
- Weeks 4, 8, 12, 16, 20: video observation of different sportsmen and women performing one particular method in table tennis playing: the forehand attack. This was chosen because of its importance in table tennis playing. The children were told what to focus on – to look at the playing styles. In addition, the children were given verbal explanations of the shots, drawing attention to key points of the stroke.
- Weeks 4 to 22: commencement of "mental-imagery training." These lasted for twelve minutes and took place 3 times a week. It consisted of:
  1) Initial relaxation (now reduced to 5 minutes)
  2) Mental readying for imagery – 30 to 60 seconds of positive statements, such as "I have had a good rest, I am clear headed, I am full of energy, I can focus on the detail in my imagery. I want to do my imagery now!"
  3) Mind/body imagery of selected skills – mental rehearsal – where the children imagined feeling themselves in the same way as they had observed during the video observation. They chose the personality from the video which they most admired. The Children were then given verbal prompts whilst carrying out this exercise in weeks 4, 5 and 6, such as, "I am clearly imagining the player in the video, etc" (Li-Wei et al., 1992, 223). After that, the children were able to mentally take themselves through the mental imagery rehearsal process, though a signal was given when each of the three sections of the imagery process should start.

Other observations with this study that are useful for the purposes of this study include the fact that during the imagery-rehearsal exercise the children were moving their heads, arms and upper body. Though this was not a requirement of the exercise, the researchers interpreted this as a sign that the children were indeed going through the stages of the imagery as planned and one that can link with research in neuroscience that explains that imagery with movement is more effective and more vivid than without (Guillot et al., 2013). Another interesting observation is that it was found in this study that mental training could be reduced to just 6 minutes three times a week. The study concluded that the most pronounced improvement was detected in the group of children that were using the mental imagery (Li-Wei et al., 1992).

Interpretation. The techniques used in Li-Wei's, et al. study are interesting. They show the processes that can be used successfully with children. However, it has to be noted that perhaps the fact that the study was carried out in China meant that some of the approaches made by teachers differ from those in western culture. Noticeable is the lack of "fun" mentioned as being important for Children in T. Orlick and N. McCaffrey's research. Also, perhaps the indoctrination of the children in the first two weeks is not usually seen in mental training methods. Whilst perhaps adults could be convinced to try something out if they are told it is good for them, children of this age, according to T. Orlick and N. McCaffrey, need more 'hands-on' experience to understand the benefits and concepts of tasks, such as relaxation, for instance. However, being directly told the benefits and value of the exercise may well be enough for some students in this age group to understand why they need to try a new method. Perhaps additional visualisation to make this point was not necessary. Additionally, it is explained in this study that the students chosen for the experiment were already considered as highly promising at their sport, so it is possible that they were already motivated enough to listen to any new methods that could improve their playing technique. As one of the few studies carried out with children, it does indeed show that techniques of mental training with children do not differ greatly from adult methods of mental training.

Illustrating the aspect concerning initial motivation in students, one more recent study of children's mental training in sports of learners aged 5 to 14 was carried out at a sports summer camp in Canada (Julien, 2002). Some of the children had been enrolled in the camp by their parents, rather than choosing the course for themselves, and therefore had little initial self-interest or enthusiasm to succeed in sport. In this case, the trainer devised a motivation metre, where students would rate from 0 to 10 different elements on the course. The results were then translated onto a cardboard metre on the wall that was visible to all. This happened by the participants drawing on the metre. Using coloured circles, the students drew an indication as to where they were at that time on the metre. This was then followed by a group discussion. Katherine Julien noticed that this seemed to promote positive thinking and integration of all into the group. Another technique that K. Julien developed was the invention of scenarios that could help the children mentally visualise events in sports, such as in tennis, golf or hockey. This is comparable to the image-scenario techniques developed by B. Green and W. T. Gallwey (Green & Gallwey, 2015), but with the addition of developing the images first on paper, the technique is nicely adapted for children. Whilst many of the techniques and methods in children's sport mental training are similar to those used with adult mental training techniques in both music and sports, there are some elements that also differ. These differences, though few, could make a large difference in the way mental training is introduced to and accepted by violin students in this age group. For instance, pedagogical approach may indeed differ in this age group. Teachers need to be positive and hopeful, building on a student's strengths and achievements. Teachers need to be genuine with their students and show they care, which can be facilitated through collaboration, providing opportunities for student contribution, designing exercises that are adjustable for each individual's needs and that are congruent with the student's personal interests. Teachers therefore need to be inventive – to build together with the student meaningful visualisations that combine a student's interests with easy-to-grasp ideas conveying concepts of the subject at hand, incorporating concepts of relaxation, violin technique, musical characters and interpretation, and mental rehearsal; to be aware that methods need to be adaptive and develop along with the student's growing knowledge and interest in the subject.

Interestingly, these studies indicate that once mental training skills have been established, they can be carried out for very short amounts of time, such as 6 minutes in the case of Li-Wei, et al.'s study and can be therefore realistically included into any lesson or practice session. The use of scenarios with children is also useful, which in a musical setting, could be used to develop musical interpretations and further uses of visualisation, perhaps facilitating in the connection between music and technique. Also interesting in these studies, is the fact that student observation of a task accompanied by verbal explanations by the teacher, is effective with children. Additionally, the development of keywords or points of reference that have been developed through visualisation exercises could be very useful in violin teaching, where a short word could replace an entire explanation and could even be given whilst a student is playing as an effective prompt for technique correction, musical interpretation and focus. Whilst there is a dearth of research in this area of study, it seems clear from the studies conducted in the context of children's sport, that mental training, combined with physical practice, can also positively influence performance standards and learning potential in primary school-aged students.

It can be concluded from the combined research that the approach or attitude taken by the teacher to lessons is important and is specific to the developmental age and stage of the student. However, the utilisation of mental imagery seems to surpass traditional notions of developmental stages, potentially allowing for the application of the same or similar exercises involving personally generated and skill specific mental imagery across different age groups. This indicates the potential for a versatile and adaptable approach that can be effectively employed throughout various stages of development. Additionally, the following can be concluded that:

- concepts in pedagogical and developmental theory can connect to neuroscientific research connected to mental training and learning;

- mental imagery – the main component of mental training – is used intuitively from a young age, and that it is possible to bring this to a student's attention;
- aspects of mental training can be integrated within the pedagogical process in a fun and personally meaningful manner through the use of metaphors and similes;
- the pedagogical process provides an opportunity to alternate physical and mental activities in a collaborative manner;
- mental training components used in sports with younger students can be adapted for use in a musical setting;
- mental training can assist in the pedagogical process for both skill learning, improvement and pedagogical approach.

1.5. Primary School Student Violin Playing Skill Improvement Model and its Criteria and Indicators

One of the problems facing an instrumental teacher and researcher is the organisation of learning: what approach can be taken? And, in which order can the different techniques of violin playing be considered in the pedagogical process? These would seem certainly to be important issues when a new approach, such as mental training in the pedagogical process, is being applied. Another challenge, especially in scientific research carried out in the pedagogical process, is being able to assess the progress of the instrumental techniques being learnt. In much the same way as it is important for a teacher and student to acquire a perfect mental model of the sounds and techniques needed to be perfected, a teacher-researcher requires a reliable framework upon which to assess the violin techniques being learnt and perfected in the pedagogical process.

This chapter will address these concepts. In order to research the improvement of the skill of violin playing, it is necessary to form assessment criteria and their indicators and create a model, to assist in the sequential integration of mental training for the improvement of the skill of violin playing in the pedagogical process of primary school-aged violin students.

Before detailing the concept of the model, it is necessary to note that the process adhered to therein is based on the pedagogical-cognitive-neuroscientific concepts alluded to earlier in this thesis: that the process of learning is holistic and humanistic – based on the physical and psychological needs of the individual learning; that, as John Dewey points out, the process itself and the goal of teaching and learning are one and the same; that the process includes personal relevance and reconstruction of experience (Dewey, 1897), rather than abstract contexts that are false or meaningless to the learner (Engeström, 1987); that the pedagogical process takes into consideration as one of its main constructs the relationship of the inner and the outer, which are so dependent on each other and are constantly adjusting and changing in accordance with each other (Vygotsky, 1987; Leontiev, 1977; Kolb & Kolb, 2012); that the pedagogical process therefore allows for experimentation and self-actualisation of personally-relevant and therefore also personally-constructed goals; that the pedagogical process encourages the process of self-assessment, constructive self-reflection and reduces the need for external evaluation. In this way, it is envisaged that students find their own independence and personal methods of self-education (e. g. Špona & Čamane, 2009) that will be relevant to the student life-long.

This pedagogical process could be described in terms of a repeating cycle, or, more specifically, a spiral that is continually growing: a process that repeats, but never exactly in the same manner, since it becomes enriched by each component in that spiral, so that eventually all components interact and progression of learning, and indeed development, takes place.

David Kolb's experiential learning spiral, which is derived from his experiential learning theory, describes a similar process. His theory describes a learning process "driven by the resolution of the dual dialectics of action/reflection and experience/abstraction" (Kolb & Kolb, 2012, 1215). D. Kolb's process begins with a concrete experience (CE), followed by reflective observation (RO), abstract conceptualisation (AC) and active experimentation (AE) (see Fig. 21).

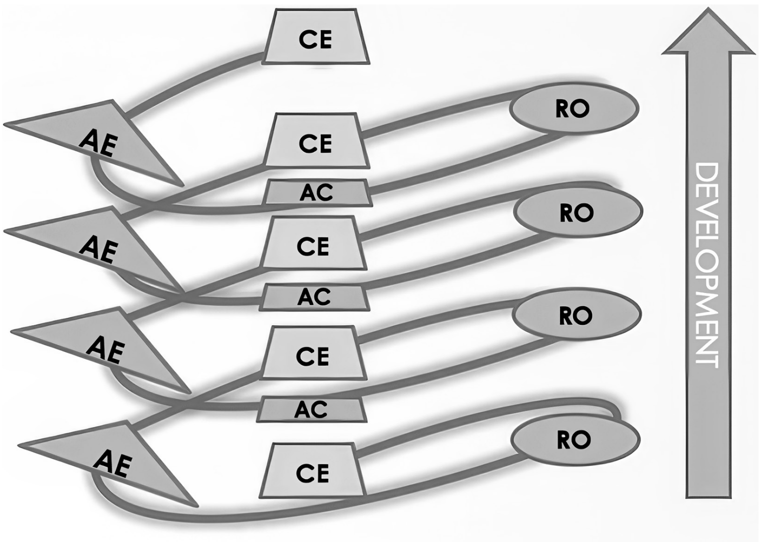


Figure 21. **Experiential learning spiral** (after D. Kolb, 2012)

D. Kolb's theory could be compared to being close to the concept of mental training, wherein too the alternation of two opposite forms of operations: the mental and physical appear as the basis of the concept of the theory.

Development of a model of mental training. As already mentioned in this dissertation, mental training distinctly seeks to create an awareness of the identification and requirements of a task mentally, followed by its mental rehearsal, before actually carrying out the task physically and that this can be based on the feedback and feedforward processes identified in the research in neuroscience directly connected to playing and learning a musical instrument. Indeed, the process of mental projection of actions and decision making has been traced in the simplest of neural structures present even in the common house fly (Armstrong, 2013, 33:25) and the interplay between internal and external dynamics (Takahashi, 2008). This interplay between the internal and external in a model with mental training can be shown as an alternation, a backwards and forwards process, between mental and physical processes (see Fig. 22).

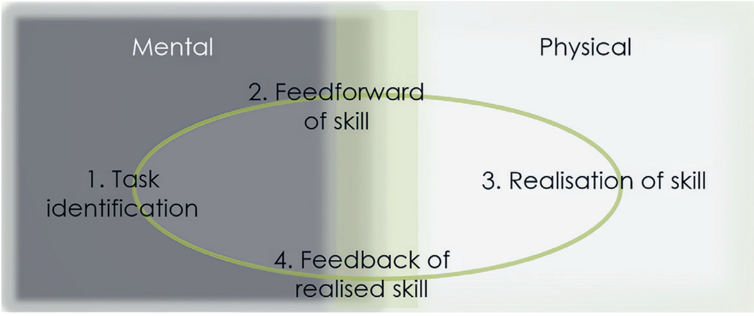


Figure 22. **The dichotomy of mental and physical processes, connected through feedback and feedforward processes** (F. M. Vilnite)

In this preliminary model above, it is possible to understand that the dichotomy of mental and physical, shown in dark and light colours in figure 22, are connected by feedforward and feedback processes. In mental training, feedforward processes are consciously created by mental imagery connected to the skill being anticipated. Feedback processes consist of a reflection on what has been realised physically. As has been discussed, this recall process also creates mental imagery and now a comparison of the two imageries – the imagery occurring before the action, and the imagery created by remembering the actual action – can be made.

The following cycle shows how the aforementioned mental imagery can be used in this process (see Fig. 23).

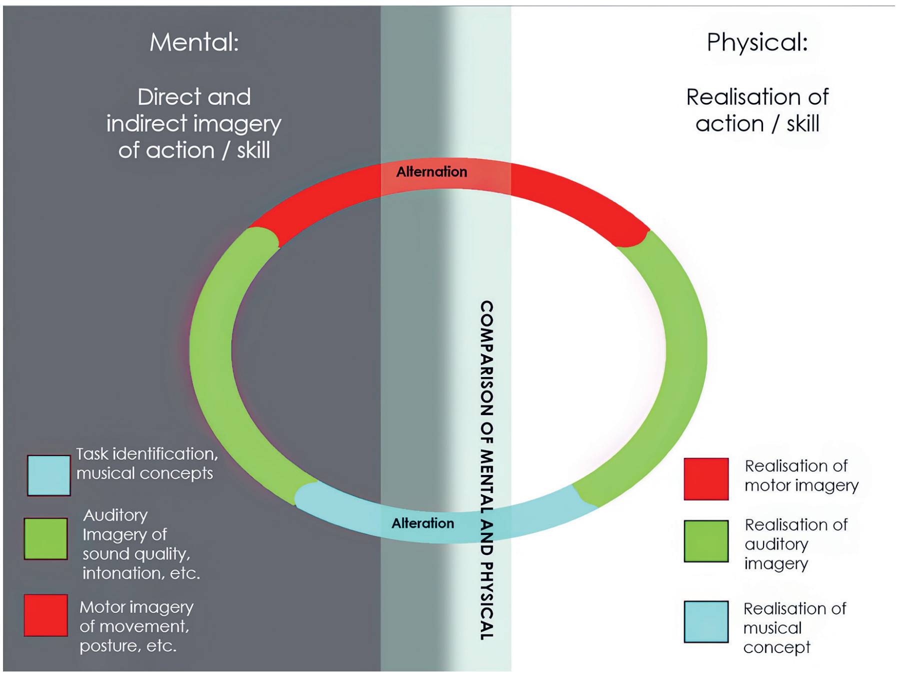


Figure 23. **Mental imagery as a basis of the cycle of mental training** (F. M. Vilnite)

Here, the two modes of mental, the dark-coloured left-hand half of the diagram, and physical, the light-coloured right-hand half of the diagram, are again represented as a background to the cycle. The cycle begins on the bottom left-hand side with task identification of musical concepts – shown in blue, followed by auditory imagery of that task – shown in green, followed by motor imagery – shown in red. The cycle then begins to move into the right-hand side of the diagram, where the alternation process from mental to physical begins. Then, the actual realisation of the motor imagery occurs as physical movement – shown in red, and realisation of the auditory imagery occurs as an audible sound – shown in green. Whilst the movement and sound will occur simultaneously, it is most likely, and according to the literature on multi-tasking, that the student's attention whilst carrying out the physical action will switch from one mode to another – that is the switch from perceiving or feeling the type of movements made and perceiving the sounds produced. The process then moves into the blue area of the cycle, which represents the feedback of the combination of the movement and sound, during the actual playing, which is then compared to the initial mental imagery produced at the beginning of the cycle. This comparison is shown in the middle area of the cycle. It is at this point that, after the feedback and comparison of the mental and physical conditions, that the cycle can start again. This time, however, alteration of the original feedforward mental imagery occurs.

Aside from deliberate, *direct* mental imagery, that is, the purposeful imagination of the skill, or skill component, non-deliberate, *indirect* mental imagery, such as that created by metaphors, language usage, and observation can also be included on the left-hand side of the diagram. This type of imagery has been discussed in previous chapters and links to the research on mirror neurons, spontaneous formation of mental imagery in response to verbal stimuli in neuroscience, and, in pedagogy, components from Albert Bandura's social learning theory – especially that of "modelling." Additionally, the indirect imagery, such as metaphors and similes, help to create student personal relevance and assist the student in self-actualisation and indeed collaboration in the pedagogical process.

To be able to complete a model of mental training and to make the present cycle into a spiral that could be used for the growth and improvement of the separate techniques of violin playing, it is necessary to build a set of criteria that are representative of the essential basic techniques of violin playing. These criteria can also double as providing the basis assessment of student playing skills in the empirical part of this study.

Formation of assessment criteria. There is a dearth in current literature that summarises the techniques of violin playing by providing a hierarchy of the basic skills of violin playing for their objective assessment. Much existing assessment criteria derive from criteria used in examination situations, which, as Stephen F. Zdzinski and Gail V. Barnes note, is frequently unspecific to the playing of the instrument being evaluated (Zdzinski & Barnes, 2002). Whilst these criteria would perhaps serve as guidelines for the standard of playing, by helping to remind an examiner of the general concepts of performing music, it may mean that examiners who are not string specialists themselves, evaluate a performance quite differently from an examiner that has more experience in the field of string playing. Indeed, the reliability of music performance assessment is often criticised as being subjective (Hallam, 2006). Interestingly, Susan Hallam also notes that teachers and students often concentrate on different aspects of musical performance: that teachers often judge an instrumental player's performance on technical accomplishment, whereas students often regard the expressiveness as being as important, or more important than technical ability.

The UK's Trinity College, London, grade examinations evaluation criteria outline just three areas: (1) fluency and accuracy, which includes pulse and rhythm, (2) technical facility, which includes "tone control" and (3) communication and interpretation, which includes stylistic understanding. The eight graded examinations that exist in the UK are externally evaluated, graded examinations that can be taken as frequently or as rarely as the student requires, but which approximately equate to the number of years of study in a Latvian music school, if the UK examinations are planned yearly. Evaluation of "technical work," in these graded examinations which *is* instrument specific, but only from grades 5 to 8, is applied purely in the section of the exam which consists of scales and arpeggios. Here, martelé (grade 5), spiccato (Grade 6), "hooked bowing"- a dotted quaver followed by a semiquaver which are separated, but in the same bow (grade 7) and all three bowing types (grade 8) are specified as requirements (*Trinity College London Strings Syllabus*, 2015). Interestingly, however, these technical requirements are specific to the requirements of those exams and do not evaluate the basic technical components that assist in these requirements taking place – such as balanced posture, or relaxed arms and hands, bow divisions, etc.

In an attempt to categorise the aural aspects of string playing for performance evaluation, Zdzinski and Barnes identified the following criteria:

- articulation/tone
- rhythm/tempo
- intonation
- vibrato
- interpretation/musical effect (Zdzinski & Barnes, 2002).

In his book on violin playing, violin pedagogue Ivan Galamain acknowledged that violin technique and interpretation is founded upon three basic components of music – tone, pitch and rhythm – realised in violin playing as "beauty of tone, accuracy of intonation and precise control of rhythm" (Galamian, 1962, 2). Simon Fisher identifies: "intonation, tone production, rhythm and articulation, coordination, relaxation, as well as the easiest possible working of arms, hands and fingers" (Fischer, 1997, VI). Thus, criteria from these sources can be extrapolated to devise both a hierarchy of musical-technical components (see Fig. 24), and their violin-specific indicators.

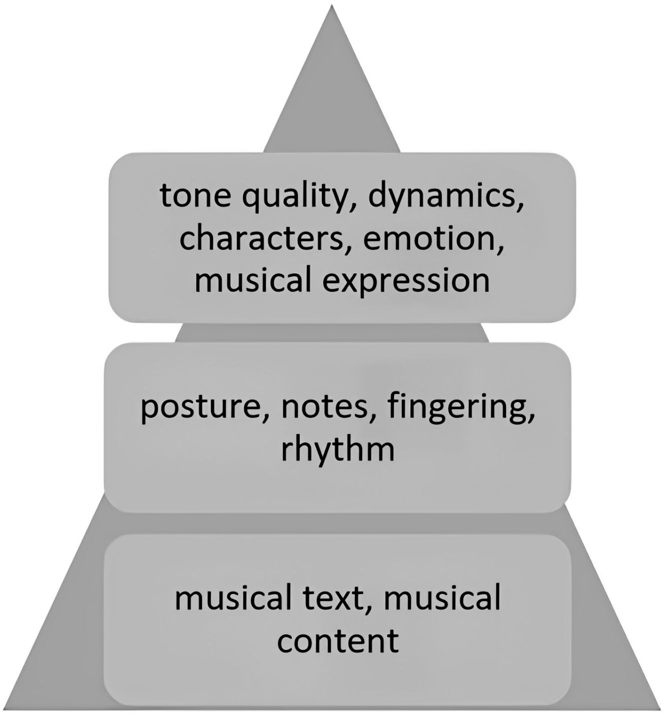


Figure. 24. **Hierarchy of musical-technical components**

This hierarchy is based on the order in which music is learnt in the pedagogical process – which begins with acquaintance of the musical text and the basic understanding of the musical concepts therein. This stage may involve student sight-reading of the piece or listening to a recording of it. Ideally, the student at this stage needs to gain a concept of the characters and emotions that can work as a catalyst, or inspiration for further learning of the musical work. This is followed by the necessity to understand how each note in the musical text sounds, and how each of these notes needs to be fingered. Next, the rhythm is worked upon in more detail. Throughout these basic processes, an awareness may be drawn to posture, so that the fingering and technical requirements, such as bowing and bow division, can be accomplished more comfortably and with a sense of ease, since there is now a purpose for their accomplishment. Interestingly, Simon Fischer remarks how most technical processes, such as these, in violin playing remain the same throughout the different stages of violin playing (Fischer, 1997). After these basics are secure, it is then possible to concentrate in more detail on the characters and emotion that could be regarded as contributing to musical expression and interpretation.

In order for these musical-technical components to be used as a basis of evaluation criteria, from which improvement of student violin skills can be measured, it is necessary to categorise the components and create violin specific indicators for them. Grouped into six main categories: 1) musical text and fingering, 2) Rhythm, 3) Posture, 4) Tone Quality, 5) Dynamics, 6) Characters, emotion and musical expression, it is possible to construct from the combined literature valid indicators for each of the criteria (see Table 4).

Table 4. **Violin playing skill criteria and indicators**

Criteria	Indicators
Musical text and fingering	Notes were played with awareness of key signature and good intonation. Awareness of the fingering and of relationships between fingers and distances of shifts between positions.
Rhythm	Notes played in time with deliberate bow divisions and speeds
Posture	Relaxed posture that makes it easy to use arm weight in bow, have straight back, flat shoulders, and bow hold that allows arm weight to enter the bow. Left hand and wrist in straight line with the left elbow; fingers are rounded and over the string.
Tone quality	Deliberate use of sound points, arm weight, correct bow division, deliberate use of vibrato, bow levels are well used.
Dynamics	Deliberate use of sound points, bow speeds and balance of arm weight
Characters, emotions, musical expression	Contrasts of dynamics and tone colours, awareness of phrases and associated bowings and articulation. A combination of the different technical components.

In the first category of the criteria: musical text and fingering, the indicators include an awareness of the key signature of the piece being learnt and with good intonation, so that minor thirds are not played too sharp, for instance (see Zdzinski & Barnes, 2002) and so that the key of the piece is recognisable. Additionally, if this is correct, then the spaces between the fingers will be correct. However, an awareness of these distances needs to be not confined to one string, but across the strings, so that larger intervals and any double-stopped notes are in tune (see Fischer, 1997).

In the second category: rhythm, bow divisions and coordination are relevant (Galamian, 1962). The third category: posture, has been outlined by Louis Bergonzi, who describes aspects of the components of posture for beginning violinists, including using the metaphor of a clock to illustrate how the left arm should be pointing towards 10 ‘o clock and how the central line of the body needs to be at 12 ‘o clock; the unbroken line between the left elbow and the base of the little finger and the way the left hand fingers should be rounded over the strings (Fischer, 1997).

The fourth category: tone quality, is characterised by the weight of the bow, bow speed and sound points – the area in relation to the bridge that the bow is drawn on the string (Fischer, 1997). Vibrato has been omitted from this study, since the novice violinists in the empirical part of this study did not use it. Vibrato is often introduced in violin playing at a later stage, so that intonation can be easier, so a sense of ease can be established in the left hand and so that the left thumb is not applying too much counter-pressure to the hand (Fischer, 1997). When these can be established, vibrato can be introduced more easily. The fifth category: dynamics, is often categorised together with tone quality, since it also involves the use of sound points. Yet, contrasting dynamics also requires the player to be able to change sound point effectively (Fischer, 1997). The sixth and last category: characters, emotions and musical expression, is one of the most neglected aspects in the violin methodology. A short paragraph is devoted to the idea of “playing from the inside out” (Fisher, 2013, 226), where the idea that the desired sound needs to be first pre-heard before being played, in order to play musically. However, the author then continues to talk about technical challenges, and does not continue to the idea that the concept of characters and emotions can lead to the reason for integrating varied techniques that in turn produce musical expression. This sixth category is therefore indicated by the variation of techniques that produce the musical expression – even though the techniques themselves may not be the initial instigator of the musical expression.

These criteria and indicators were then organised into three levels, allowing for evaluation of each of the separate criteria.

Based on the combined literature, the criteria were then organised into three levels, these levels could then be used to evaluate the level of student playing. The criteria, indicators and three evaluation levels are shown in Table 5.

Table 5. **Violin skill evaluation criteria, indicators and levels**

Criteria	Indicators	A	B	C
Musical text, fingering, intonation	**Relationships between fingers**	Fingers were deliberately placed with the correct distances between fingers on one string and across the strings. The left hand was relaxed	Finger distances were mostly used deliberately on one string, but not across the strings. The left hand was mostly relaxed	Finger distances were not planned and distances were frequently changed during playing. The left hand was not relaxed
Rhythm	**Bow division**	Rhythm was precise with deliberate use of bow division and bow speeds	Rhythm was generally precise, but bow divisions were not accurate.	Rhythm was not precise and bow divisions were not deliberate.
Posture	**Left hand**	Hand and wrist in line with left elbow; fingers are rounded over the string. Thumb was pointing upwards and not pressing on the neck of the violin	Hand and wrist were in line with elbow, but fingers were not rounded over the string. Thumb was generally pointing upwards and mostly did not press too strongly	Hand and wrist were not in line with elbow and fingers were not rounded over the string. Thumb was not pointing upwards and was pressed in to the neck of the violin
	Right hand	Thumb was bent and knuckles were held higher than the bow	Thumb was not bent, but knuckles were higher than the bow	Thumb was not bent and knuckles were lower than the bow
	Whole body	Shoulders are flat, violin is pointing at 10 ‘o clock, nose at 12 ‘o clock. Violin head at same level as player’s nose	Shoulders are almost flat, but violin does not point at 10 ‘o clock. Violin head is almost on the same level as player’s nose	Shoulders are not flat, violin is not at 10 ‘o clock and violin is not held at the level of the player’s nose

Criteria	Indicators	A	B	C
Tone Quality	**Sound points**	Deliberate and purposeful use, bow was drawn parallel to the bridge, except for deliberate changes of sound point and the right arm weight was balanced	Use of sound points was not so deliberate, but the bow was generally straight and not pressed too much	Non-deliberate use of sound points. Bow was not straight and was crossing several sound points, resulting in an unfocused sound. The bow was pressed too much
Dynamics	**Dynamic contrast**	Dynamic contrasts were audible and deliberately controlled by use of sound points, bow speeds and arm weight	There were subtle dynamic contrasts, which were occasionally controlled deliberately by bow speeds and arm weight	There were no audible dynamic contrasts
Characters, emotions, musical expression	**Mixture of sound quality, dynamics, articulation, artistic use of tempo, rubato.**	A range of different techniques are mixed effectively and contrasting characters are discernible	Some varied techniques are employed, but no contrasts are discernible	Varied techniques were not employed and contrasts were not discernible

Creation of a violin skill improvement model. It is now possible to transform the cycle of mental training developed earlier in this chapter into a spiral violin skill improvement model with mental training (see Fig. 25).

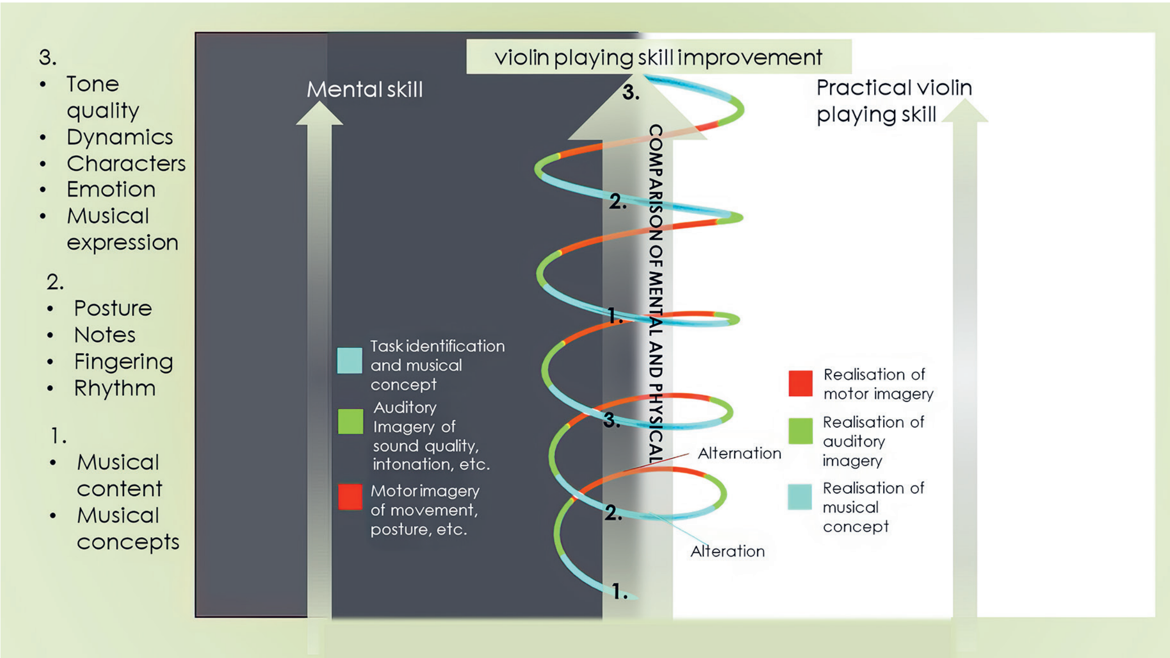


Figure 25. **Violin playing skill improvement model**

The process of the spiral is separated into the three stages, which formed the hierarchy of musical components identified earlier (see Fig. 24) and the basis of the criteria and indicators (see Table 4). For each stage, a full turn of the spiral can be made and repeated, if necessary. In the second stage, for instance, the circle may be repeated each time for concentrating on each of the components in that stage individually. Once they have been mastered individually, they may be combined, after which, the spiral progresses onto the next level. As before, the spiral travels through both the left-hand side, which is concerned with mental operations and feedforward processes, using mental imagery of different types, through to the right-hand side of the model: the physical and the realisation of the imagery. The comparison between the mental imagery at the beginning of the process and the actualisation of the practical violin playing skill again shown in the middle of the spiral. After the three stages have been completed the first time, they can be again repeated – but this time at a more advanced standard of playing. It is anticipated that each stage and turn of the spiral may last differing amounts of time – depending on the level, length of music being worked upon, or the mood and preferences of the student; that each turn in the spiral may last several minutes, or even a few seconds, when the process becomes more automated. Additionally, it is anticipated that not all stages will be completed in the same lesson, especially in the beginning of the specialist music primary school pedagogical process, due to time constraints and perhaps due to the necessity to concentrate on basic skills at the beginning of learning. Overall, it would seem that the spiral needs to be fluid and dynamic – hence the use of the spiral form – to enable a personally-relevant and self-actualising improvement of violin playing skills.

It is now possible to identify:

- the cyclic nature of learning; that through each repetition of the cycle, learning transforms and grows.
- That the interplay between and alternation of the inner and outer processes is at the basis of human thought processes and at the basis of mental training in a pedagogical environment.
- That mental training is based on the formation of mental imagery that acts as both feedforward and feedback to and from physical action.
- That it is possible to create a model that represents these concepts that can assist in student pedagogue collaboration and student self-actualisation.

Considering the significance of the combined literature in pedagogy, psychology and neuroscience and the cyclic nature of learning and skill learning, which directly involves the alternation the inner and outer processes, it is important that a student's individual physical and psychological needs, as well as opportunities for self-actualisation are observed during the teaching and learning process. Indeed, a student's enthusiasm, interest, and active engagement in the learning process have a profound impact on their learning lifelong. Thus, a pedagogue observation table was developed (see appendix 6) that would assist the pedagogue keep track of these components and help in identifying aspects that could be improved or adjusted during the pedagogical process. Eight criteria were developed to assist in assessing different aspects of physical, psychological and socio-emotional well-being: 1) Willingness to create personally-relevant mental imagery; 2) Independent use of mental training; 3) Punctual attendance of lessons; 4) Willingness to arrange extra lessons; 5) Willingness to participate in group activities; 6) Eagerness to perform in front of others; 7) Positive attitude towards challenges; 8) Regular practice habits. Each criteria could then be split into three levels (see Table 6. criteria and indicators below).

Table 6. **Student Interest, Physical, Psychological and Self-Actualisation criteria, indicators, and levels**

Criteria	Description	Domain	High	Medium	Low
Willingness to Create Personal Imagery	Creation of own imagery without prompting	Psychological	Student consistently creates own imagery without prompting	Student occasionally creates own imagery	Student rarely creates own imagery
Independent Use of Mental Training	Engagement in mental training independently	Psychological	Student actively and consistently engages in mental training	Student sometimes engages in mental training independently	Student rarely engages in mental training independently
Punctuality to Lessons	Timeliness in attending lessons	Socio-Emotional	Student always arrives punctually to lessons	Student usually arrives punctually to lessons	Student frequently arrives late to lessons
Willingness to Arrange Extra Lessons	Eagerness to schedule additional lessons	Socio-Emotional	Student eagerly arranges extra lessons when needed	Student occasionally arranges extra lessons when necessary	Student rarely or never arranges extra lessons when necessary
Active Participation in Group Activities	Engagement in collaborative activities	Socio-Emotional	Student actively participates in group activities	Student participates in group activities to some extent	Student rarely participates in group activities
Eagerness to Perform in Front of Others	Enthusiasm for performing in public	Socio-Emotional	Student eagerly performs in front of others	Student performs in front of others with some hesitation	Student avoids performing in front of others
Regular Practice Habits	Consistency in practising the violin	Physical	Student consistently practises the violin regularly	Student practises the violin regularly to some extent	Student rarely practises the violin
Positive Attitude Towards Challenges	Optimistic approach to facing difficulties	Psychological	Student maintains a positive attitude towards challenges	Student exhibits a mixed attitude towards challenges	Student often displays a negative attitude towards challenges

Based on the analysis of the insights from the scientific literature and the examination of observations in the literature and by professional violinists and pedagogues in the first chapters of this dissertation, it can be concluded that:

- The concept of mental training involves becoming aware of the mental and physical processes connected to skill learning and musical creativity.
- Mental imagery use is central to this process.
- Through understanding the basis of the components of mental training in neuroscience and psychology, it is possible to identify connections between mental processes, learning and concepts in pedagogy: that the diversity and synthesis of sources assists in illustrating and strengthening each field and in so doing also helps to identify logical expansion of mental training into pedagogical processes.
- Mental training in the pedagogical process can, through the use of both deliberate and non-deliberate mental imagery, provide an opportunity for teacher-student collaboration and student personally relevant musical interpretations.
- Mental training can provide a vehicle for the awareness of reduction in teacher interference in student thought-processes and stress-related aspects.
- Understanding the basis of mental training can facilitate the understanding of neural-psychological phenomena in learning and facilitate the introduction of concepts during the pedagogical process that enhance cognitive functions and skill development.
- Aspects of mental training, such as cognition and imagery of goals and recognition of progress made can increase activation of reward centres in the brain, improving motivational aspects.
- Mental training can help to bring into awareness and develop consciously auditory-motor connections necessary for playing an instrument to a higher standard.
- Based on textual and conceptual analysis, together with a synthesis of research from multiple domains, mental training and humanistic pedagogy bear many similarities
- Mental training can provide a framework for applying concepts of humanistic pedagogy and individual approach.

2. THE EFFECTIVENESS OF USING MENTAL TRAINING IN THE PEDAGOGICAL PROCESS OF PRIMARY SCHOOL VIOLIN STUDENTS

2.1. Empirical Research Plan and Methods

During the course of the literature analysis, it became apparent that there is little literature on mental training for novices in all subject domains. Additionally, in the extant texts that address mental training with already-trained practitioners, the explanations for its successful positive results are not addressed. In short, the existing literature on mental training illustrated that the utilisation of mental processes was successful but did not provide an explanation as to what was actually happening, what mental changes occurred, with the mental processes that were being trained and how that relates to the practical skills being practised. Therefore, the first half of this thesis concentrated on filling that gap, by identifying and synthesising research from multiple domains into a harmonic whole. It is perhaps significant that mental training, together with its basis in mental processes identified in the literature in neuroscience, bears many similarities to concepts in humanistic pedagogy: including its individual approach, its encouragement of unconditional positive regard, the importance it gives to personally significant learning approaches, the exploration of the relationship between the inner and the outer. It is the combination of evidence, however – the synthesis of literature from the different fields, not purely a textual and conceptual analysis of existing literature – that enhances the significance of this research, not only expanding the concept of mental training itself, but also provides the foundation to the empirical section of this thesis (see Fig. 26).

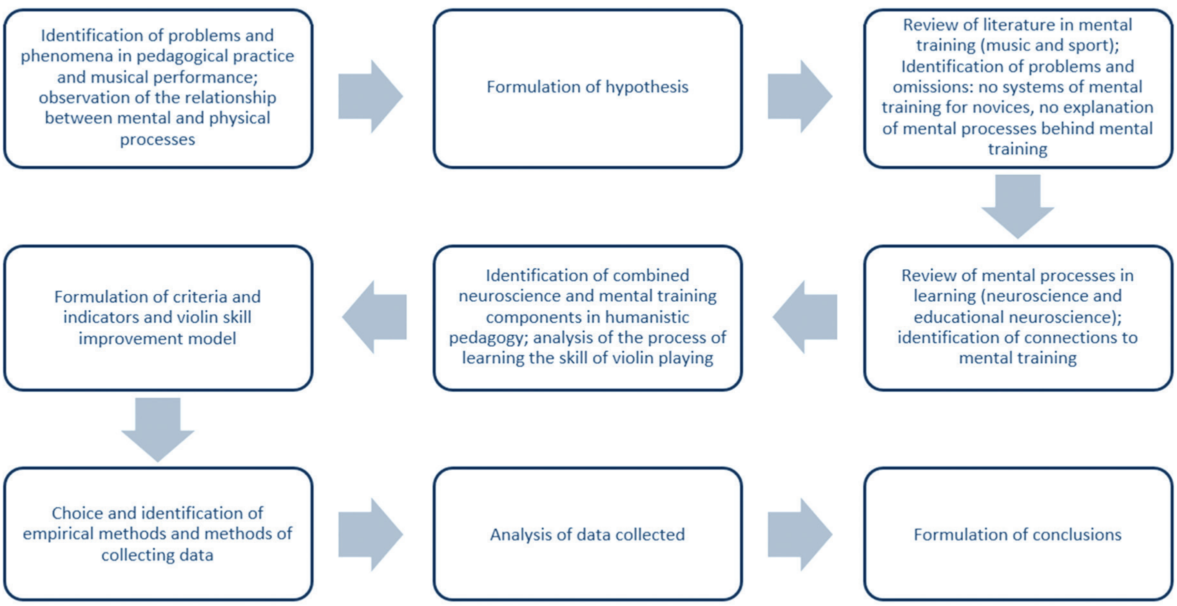


Figure 26. **Progression and general plan of the theoretical and empirical research**

To test the hypothesis of this dissertation, it was necessary to devise a mental training system (see chapter 2.3) specifically designed for use in the violin teaching and learning process of primary school-aged students and then to measure its effectiveness in improving the separate components of violin playing, as outlined in the criteria and indicators. Single-subject research was considered necessary for this study. This empirical research design has been employed in both psychology and sports psychology (Barker et al., 2011) and education (Riley-Tillman & Burns, 2009), where data is analysed from each participant separately, and where a baseline level of each participant is established pre- a method or system is used and then measured again post-the use of a method or system.

It was therefore necessary to decide on the methods of measuring the skills of violin playing as laid out in the criteria and indicators (see chapter 1.5).

Research methods

Qualitative methods

- Teacher observations of violin playing skill translated onto an evaluation card (see appendix 1), carried out according to the criteria and indicators outlined in chapter 1.5.
- Teacher observations of the individual student in the lesson situation.

Quantitative Methods

1) Evaluation of intonation, using the computer programme *Melodyne 4*.
2) Evaluation of dynamic contrasts, using the computer programme *Audacity*, version 2.1.1.0.
3) Evaluation of rhythm and tempo (pulse), using the computer programme *Melodyne 4*.
   Statistical calculations and analyses: *google sheets* and IBM SPSS statistics 21.

Participants

The participants in this study consisted of 9 violin students in a specialist music primary school, Latvia. Eight of the students had been studying the violin for between two and five years, having had two lessons of twenty minutes duration for the length of their studies at the school. One student had already studied for five years at music school before continuing studies in the specialist music primary school.

In order to carry out the empirical research, it was necessary to decide on its design and devise a research plan. Single-subject research was considered appropriate for this study. This empirical research design has been employed in both psychology and sports psychology (Barker et al., 2011) and education (Riley-Tillman & Burns, 2009) where data is analysed from each participant separately. In order to test the effects of an intervention – or in this case the mental training system – a baseline level of each participant needs to be established before the system is used. In this case the different components of the skill of violin playing, as outlined in the criteria and indicators, need to be measured. Then, after the system has been introduced, the components need to be measured again.

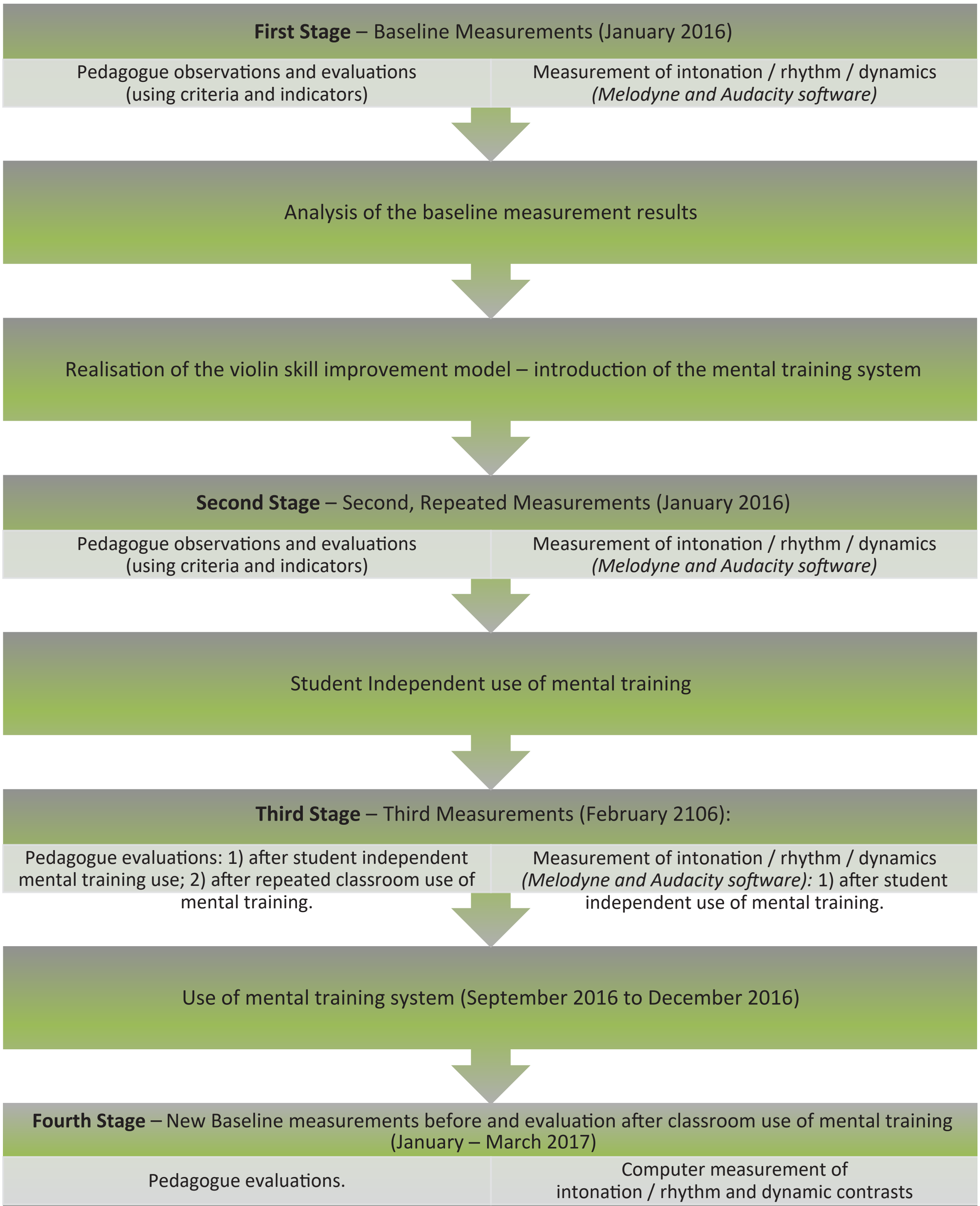


Figure 27. **Empirical research plan with students**

Thus, after the initial identification of existing phenomena in violin playing and in its pedagogical process and then some pilot testing of different mental training components, to identify the viability of a mental training system, the empirical research was organised into four student measurement phases (see Fig. 27) and a final phase where expert violin teachers (of ten or more years' experience) were interviewed to determine the usefulness of the mental training exercises in an international context:

1) Baseline measurements made for each student, to identify their existing skill level. (Pedagogue assessment and independent pedagogue assessment, analysis of intonation and rhythm using *Melodyne* 4 – December 2015 to January 2016)
2) After the first systemised use of mental training, based on the violin skill improvement model, had taken place, evaluation and measurements were made a second time. (Post mental training pedagogue (author's) assessment and independent pedagogue assessment of audio recordings, plus analysis of intonation and rhythm using *Melodyne* 4)
3) After further classroom use of the mental training routine, second measurements were made. The results of these measurements were then compared with the results from phases one and two. (Pedagogue evaluation and intonation and rhythm analysis using *Melodyne* 4 – February 2016.)
4) After continued use of mental training for the remainder of the year new measurements took place before and after classroom use of differing, additional mental training routines. (January to March 2017 and September 2017.)
5) Expert violin teacher interviews (June 2023).

Schedule of the research. The empirical part of the research took place between January 2016 and May 2017. From September 2015 to December 2015, some mental training components had been introduced into the teaching and learning process – for example, basic concepts of metaphors, visual and auditory imagery – mainly as pilot research and observations, to assess the viability of mental training in the specialist music primary school violin teaching and learning process, but had not been presented in a systemised manner. Deliberate organisation and purposeful integration of mental training into the pedagogical process began in January 2016.

Description of the schedule of the empirical research. Baseline measurements were first made using the pedagogue evaluation card (see appendix 1) and computer software analysis of the students' playing at the beginning of January 2016 (Stage 1). After the first use of the mental training routine – which occurred straight after the baseline measurement – a second measurement was made, again using the computer software and with pedagogue evaluation (stage 2). This was done to determine the short-term effects of the mental training. Students were then encouraged to continue using the mental training in their private practice and were again assessed one month later (February 2016), using the same methods: computer software and pedagogue evaluation (stage 3). From September to December 2016, mental training routines were continued independently and in lessons. Stage 4 evaluations of student skills occurred from January 2017 to March 2017 using different mental training exercises from the system, using a combination of pedagogue observations and computer-aided measurements again in September 2017, using pedagogue observations and computer-aided analysis of intonation and rhythm. The final stage of the research included interviewing expert violinists to ascertain the usefulness of the mental training exercises provided in this study and identify any similar issues and aspects that they may have encountered during the violin teaching and learning process.

The research was conducted in full compliance with the prevailing ethical guidelines set forth by the institution (Riga Teacher Training and Educational Management Academy) during the research period. Parents of the students gave written consent for the students to partake in the research. Measurements and teacher evaluations of student playing took place in the usual violin lessons. In most cases, each violin lesson lasted for twenty minutes, twice a week. In some instances, the violin lessons occurred once a week for forty minutes. Student confidentiality during the research was upheld and students are represented in this research by a unique number issued by the author of this dissertation.

Use of computer software. To analyse the students' playing using the computer software, it was necessary to record each of the student's playing. This was done initially on a Samsung Galaxy J5 2015, which produced .wav files and then on an Apple iphone 5s, which produced .m4a files. These audio files were then transferred into the relevant computer software, running on an Apple Macbook Pro, with the operating system *El capitan*.

Melodyne 4. Produced by celemony.com, *Melodyne* has been used by industry professionals to analyse and adjust the pitch of and tempo of performances. Currently little used in academic research, save for studies, such as Ryan V. Scherber's that have used *Melodyne* to adjust pitches and to test the perceptive abilities of listeners (Scherber, 2014) and in analysis of pitch drift in acapella choirs (Seaton et al., 2016), *Melodyne* does provide powerful tools for analysis (see Fig. 28). *Melodyne* first analyses the recording: the notes in the recording are shown as sound waveforms.

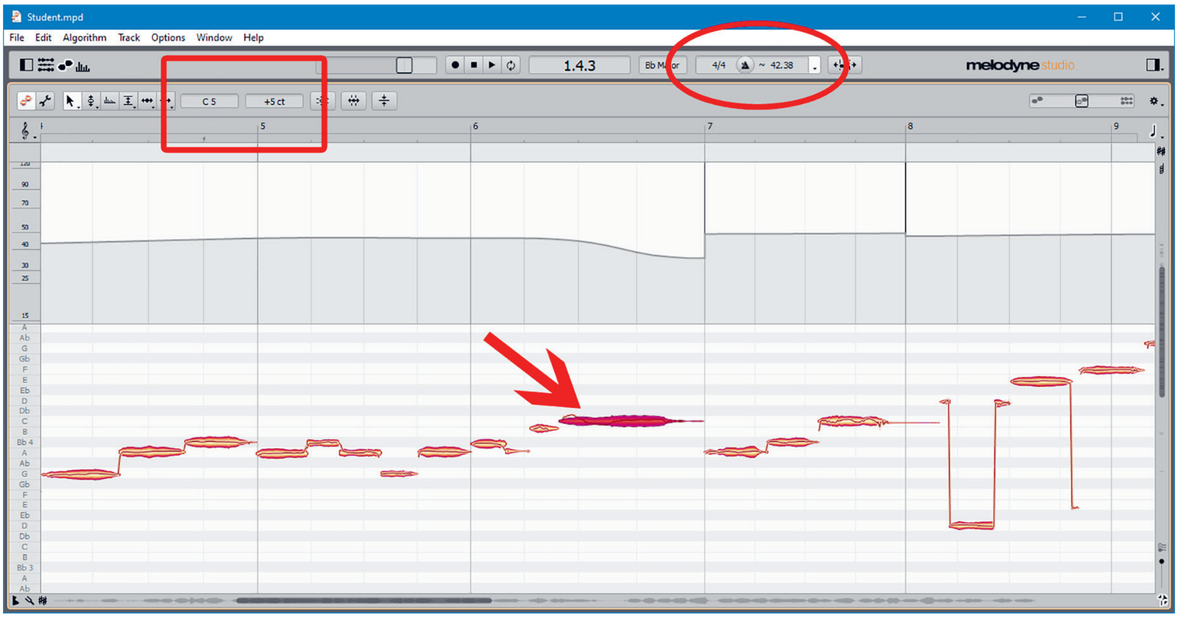


Figure 28. **Melodyne software user interface, showing tempo and pitch analysis**

When a note is selected – the note selected is shown by the arrow in figure 28 – information appears about its pitch – shown in the square in figure 28 – and the beats per minute – highlighted by the oval in figure 28. Melodyne is able to detect the overall tuning of a musical work it has analysed. This means that it will detect if the violin is tuned to $A = 442$ or $A = 440$ and adjust its analysed pitches accordingly. Pitches are shown as plus or minus figures, representing the number of cents that that note diverges from that note in equal temperament. Each semitone is split up into 100 cents. A figure of zero represents the note at equal temperament; a plus figure represents a note above equal temperament and a minus figure, a note below equal temperament.

For statistical analysis the information provided by *Melodyne* needs to be entered manually into a spreadsheet.

Audacity, version 2.1.1.0. This software has a feature for detecting dynamic change: a contrast analyser, that measures the root mean square (RMS) – the square root of the mean values – for a selected passage of audio, which it measures in decibels. Two passages can be selected for comparison and the software will calculate the average RMS difference between the two samples (see figure 29). This will be useful when analysing a mental training routine that concentrates on dynamic change.

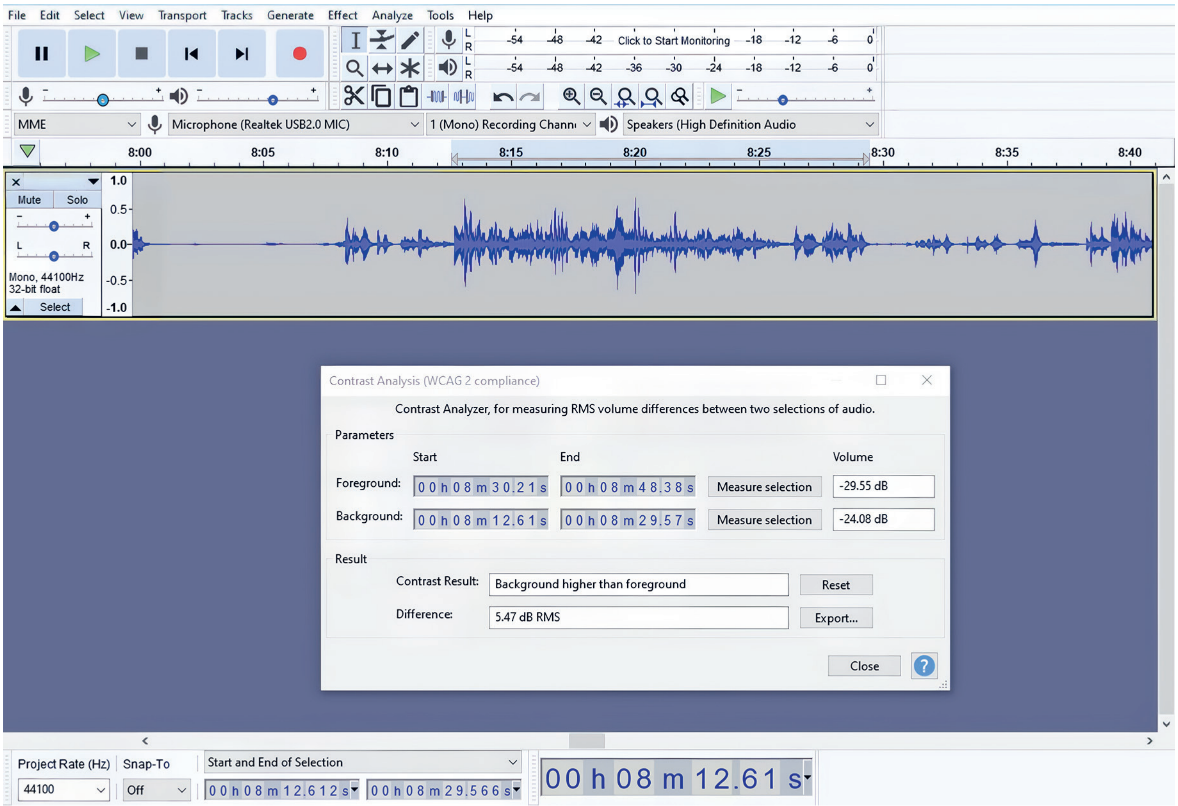


Figure 29. **Audacity software user interface and contrast analyser tool**

Evaluation and interpretation of results using the software: Intonation. Using the pitch analysis software, *Melodyne 4* – the same software used to analyse the students' intonation in this study – an examination was made of the first two bars of a commercially available recording of a professional violinist performing the Allemande from J.S. Bach's Partita No.2 in D minor. This analysis was considered necessary, since no present studies were found analysing professional violin playing in this way. The results of this analysis would then provide more detailed criteria from which to analyse, interpret and identify any future problem areas associated with intonation in this dissertation more accurately.

The software detected the overall tuning of the piece of music, and in this case, it detected that the violin was tuned to A=441 Hz.

After the first note of the passage selected for examination, which is a unison double-stopped D with the open D string, the passage does not contain any further double stops. This was purposefully chosen, since the students' etudes also did not include many double stopped notes. In accordance with the literature on the intonative tendencies of violinists, the passage seemed to be played according to Pythagorean intonation. The first ascending passage had notes that were higher than equal temperament – an average of +4.8 cents. The leading notes C sharp were heightened by an average of +21.7 cents – the highest being +28 cents and the lowest was +13 cents. The results from the pitch-analysis software were then collated and entered into a spreadsheet, from which it was possible to represent the intonation in graphic form (see Fig. 30). The zero line in the graph represents the pitch of the notes in equal temperament.

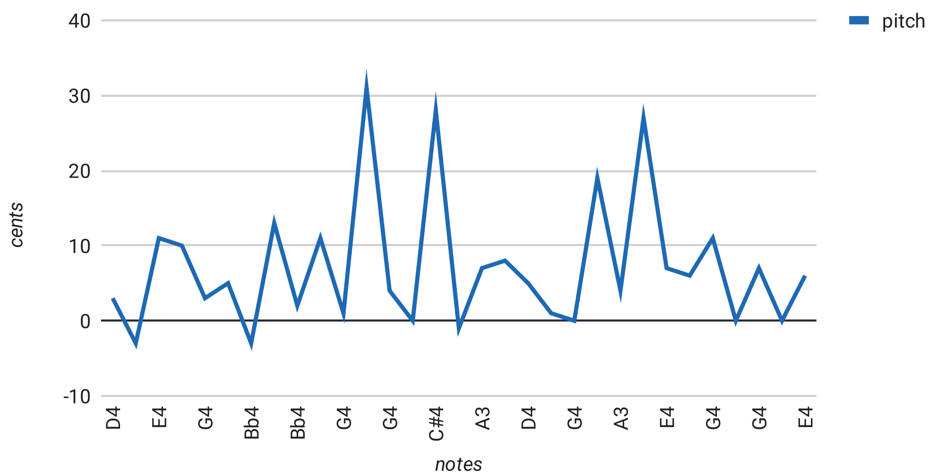
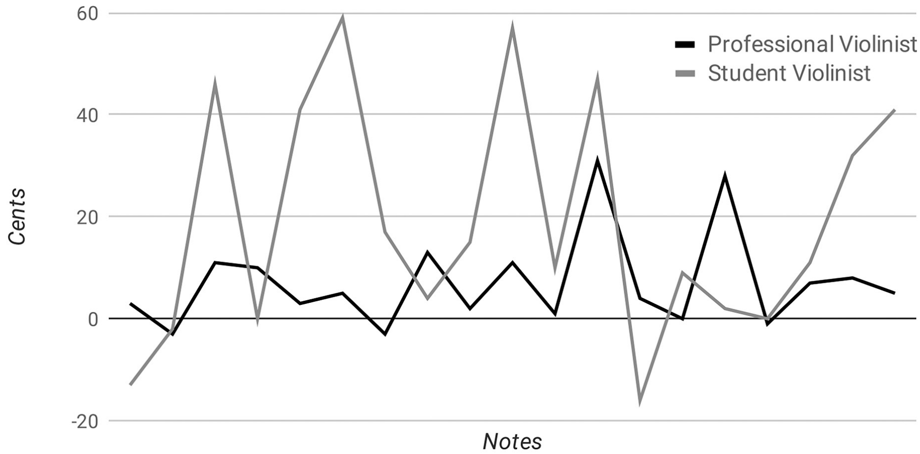


Figure 30. **Pitch analysis of professional violinist**

It is possible to observe in this graphic representation how little the intonation drops below zero – in fact only three notes went slightly below this threshold – an average of only –2.3 cents. Again, in accordance with the literature on intonation used by violinists, the minor sixth did appear lower on one occasion: –3 cents lower than the equal tempered note. In general, however, most of the notes are pitched well above the zero in equal temperament. The general range of the intonation played – measuring from equal temperament – is 34 cents. To illustrate that it is the range of the notes that is significant in statistically evaluating intonation, a comparison was made with a student performance of the beginning of a musical work in the same key (see Fig. 31). The number of the notes is the same, but the range of intonation is greater in a student performance.



	Professional violinist	Student violinist
Number of notes	20	20
Minimum cent value	−3	−16
Maximum cent value	31	59
Range (in cents)	**34**	**75**

Figure 31. **Range of intonation: comparison of a professional and a student violinist**

As can be seen, the range of intonation in a professional violinist's performance is narrower than in a student's performance. The sharpest note played by the professional violinist in this same sample is +31 cents, compared to +59 cents for the student.

Therefore, in assessing the effects on intonation of a mental training routine, a main criterion would seem to be the reduction in the range of intonation pre- versus post- its use. After analysing recordings of several more professional players, both mainstream and newly qualified, in both major and minor keys with the same pitch analysis software, it appeared that generally intonation rarely deviates lower than –18 cents from the note in equal temperament and rarely reaches above +42 cents (see Table 7), where values show the distances measured in cents from equal temperament). Interestingly, statistical analysis of the data using the Shapiro-Wilk test, revealed that 3 out of 4 of the professional violinists analysed possessed intonation that is not normally distributed (Shapiro-Wilk, P ≤ 0.001, 0.001, 0.032 and 0.158), perhaps due to the use of pythagorian intonation, which raises pitches on some notes as measured from equal temperament.

Table 7. **Intonation of professional violinists – distances of intonations from equal temperament**

Intonation (cents)	Prof. Violinist 1	Prof. Violinist 2	Prof. Violinist 3	Prof. Violinist 4
Minimum	−3	−10	−18	−1
Maximum	31	36	23	45
Range	34	46	41	46
Interquartile Range	10	7	10	16
Mean	7.19	7.98	−0.73	20.69
Std. Deviation	8.70	7.61	7.71	10.38
Median	5.00	7.00	0.00	19.00
Shapiro-Wilk P value	<0.001	0.001	0.032	0.158

Tempo / rhythm evaluation. Analysis was carried out on a professional violinist's performance to ascertain the fluctuations of tempo in a performance of a solo violin work. The same recording sample used in the intonation test was used to test the tempo (see Fig. 32).

Figure 32. **Analysis of the tempo of a professional violinist's performance**

With data extracted from the software *Melodyne,* each note can be annotated with a tempo marking in beats per minute. In figure 32, each note is annotated with a value in *beats per minute* (BPM), which represents the speed of the pulse of the bar in which that note is played. For instance, the first note is consistent with the note being a semiquaver in the pulse that the software has detected – in this case 90.38 BPM. As can be seen, the tempo fluctuates very little: minimum tempo = 89.23 beats per minute (BPM), maximum tempo = 92.59 PM. Further tests revealed that even on a longer musical excerpt, the tempo fluctuated very little, with the player's slowest tempo being 76 BPM – a range of 16.59 BPM. Again, it is the range of the tempo that is indicative of pulse: the smaller the range, the steadier the pulse. So, to measure an improvement in tempo in student performances, a reduction in the range of the tempo would be significant. The range of the pulse for this performance is shown in graphic form in figure 33 and seems to be connected closely with musical interpretation and harmonic inferences from the player (see Fig. 33).

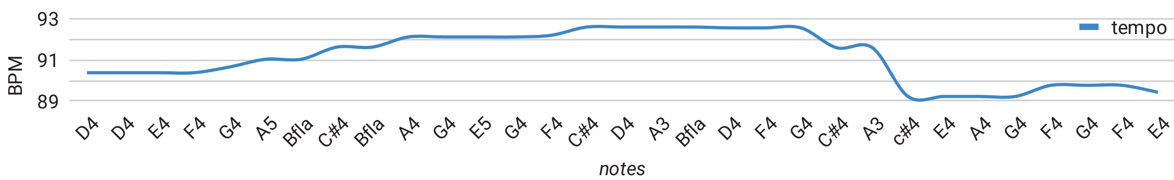


Figure 33. **Range of tempo of a professional violinist**

Evaluation of dynamic contrasts. Similarly, to ascertain the concept of dynamic contrasts at a professional level, the same recording of a professional violinist was analysed. Of course, this aspect is perhaps the most reliant on the type of recording equipment used, the acoustics of the recording studio or venue where the recording was held and indeed, how it may have been edited before the recording was released. However, it is useful to note the dynamic contrasts as a general guideline. Measured in decibels, it is interesting that the literature on sound perception suggests that an increase of 10 decibels represents a doubling of the level sound perceived. An increase of three decibels, however, indicates that double the amount of audio energy is expended, but however not perceived by humans as being twice as loud (Askland, 2011).

Comparing two sections of the given recording, then, it was possible to detect that *forte* areas as indicated in the musical score reached –31.7 decibels and *piano* areas indicated in the musical score were as low as –41.8. Interestingly, this is exactly the difference of 10 decibels identified in the literature as being perceptible as a doubling of sound between *piano* and *forte*. The *forte* section of the excerpt is then perceived as 100 per cent louder than the *piano* section, according to the literature.

In summary, a table of criteria was created of intonation, tempo and dynamic contrast (see Table 8), to assist in identifying the changes pre- versus post- mental training. However, it is envisaged that the evaluation of the intonation of student violin playing will suffice to analyse the range intonation used – that is, that their intonation should be in the range of 45 cents, if it can be considered as being in the overall range of a professional violinist's intonation.

Table 8. **Criteria and indicators for assessment of intonation, rhythm and dynamic contrast using computer-based analysis**

Criteria	Indicators
Intonation	Reduction in range (cents) / statistical analyses of data
Tempo	Reduction in range (BPM) / statistical analyses of data
Dynamic contrast	Increased difference in average root mean square (dB)

Statistical analysis of the results of the evaluation of students was carried out using *google* sheets. Each measurement was compared to each individual case: the situation of the lesson – the fact that the tests took place in normal school hours and the distractions that may have occurred because of this – extraneous sounds from adjacent classrooms, or in some cases the same classroom, the interference of the school bell marking the beginning and end of lessons and indeed the influence of the next student waiting for their lessons. Aside from the unfamiliarity of the tests themselves, any and all of these factors may have induced a more stressful or unfocused response from the student. Each student's individual preferences were also taken into account. If, for some reason, they were not able to concentrate on playing that day, due to student concerns and worries from school or personal circumstances, testing was postponed and conducted later, on a different day or at a later time, for instance. Additionally, any of these circumstances may have also influenced the results of the testing, and so in some cases the level of playing or improvement may have been affected. This was observed and taken note of during the research.

To conclude, it is necessary to point out that to date, the use of quantitative, computer software-aided data collection for the analysis and identification of the attributes of violinists' playing and for the detection of changes of these attributes after application of a pedagogical method seems to be rarely used in the literature. The author of this dissertation found no previous use of such quantitative-based data collection and analysis and no similar use of the software in papers or dissertations by different authors. Consequently, it seems logical to assume that the methods of measuring the student change pre- and post- mental training also differ from statistical models and techniques normally used with quantitative analysis of qualitatively collected data. In this dissertation, choosing the quantitative methods of measuring, however, it became clear that identification of the problems associated with student playing were more clearly definable and to describe that the difference of intonation between a student and professional performance in the terms of intonation range is a concept that seems to be a concept that is currently unexplored in the violin literature.

In conclusion, it is possible to note:

- The importance of the relationship between theoretical and empirical research.
- The possibility of evaluating intonation, tempo and dynamic contrast in a quantitative manner and that this is a relatively new development in research.
- That quantitative evaluation of intonation, tempo and dynamic contrast opens opportunities for comparison with qualitative methods of evaluation.
- There is a current dearth of scientific literature that analyses the violin playing of both professional and student violinists using qualitative and quantitative methods.
- That there is a lack of literature that assesses student violin playing using these quantitative methods.
- There are currently no studies that systematically test the use of mental training using quantitative methods and no studies that test the use of a mental training system in the specialist music primary school violin pedagogical process.

2.2. Student Violin Playing Skill Baseline Evaluations

To understand the effectiveness of mental training, it was necessary to ascertain the baseline level of each violin student. To gain an accurate impression of the starting level of the participants, and to highlight any problem areas, pedagogue observation was carried out and an evaluation card for each student was completed (see appendix). Since the criteria and indicators were arranged into three levels: *A*, *B* and *C*, a number was assigned to each level: $A = 3$, $B = 2$ and $C = 1$. This was done to enable easier statistical calculations; a higher number represents a more advanced skill.

These pedagogue evaluations were carried out at the beginning of January 2016, in the normal lesson situation, when new repertoire – etudes and scales – had been given to the students. The results in Table 9 show the results of the first readings through this new repertoire (see Table 9).

Table 9. **Pedagogue evaluation of student baseline levels**

CRITERIA									
Student	**Musical text**	**Rhythm**	**Posture**			**Tone quality**	**Dynamics**	**Characters, emotions, musical expression**	**Total**
	Intonation, fingering	**Bow division**	**L. hand**	**R. Hand**	**Whole body**	**Sound points**	**Dynamic contrast**	**Mixture**	
1	1	1	2	1	2	1	1	1	11
2	1	1	2	2	3	2	1	1	13
3	1	1	1	2	1	2	1	1	10
4	1	2	1	1	2	2	1	1	11
5	1	1	1	1	1	1	1	1	8
6	1	1	1	1	1	1	1	1	8
7	2	1	2	1	1	2	2	1	13
8	1	1	1	1	2	1	1	1	9
9	1	1	1	1	2	1	1	1	9

As can be seen from the pedagogue evaluation, each individual student has different strengths. The maximum combined score for any one student in all criteria is 24. Splitting this figure into three groups: low – 8 to 11, medium – 12 to 16, and high – 17 to 24, it is possible to see that students 1, 3, 4, 5, 6, 8 and 9 had a low score, students 2 and 7 had a medium score, and that there were no students that had a high score in these baseline measurements. Whilst it may be possible to assume that this was because students had only been studying the violin from between two to five years and so skills, such as alternating characters and the relative techniques required to achieve this – variation of tone quality, for instance – may not have yet been discussed in lessons, these baseline evaluations do also highlight a common problem outlined in the existing violin literature – that of the challenge of playing with good intonation. This problem can be clearly seen here, and how a slightly heightened awareness of intonation – such as in student number 7 – also shows an awareness, at least to some extent, of the necessary left-hand techniques to be able to reach the required notes.

Audio recordings of the students were also made in these baseline measurements which were evaluated by two more expert string players (see Table 10 and Table 11), however without the criteria associated with posture, since this was not assessable on audio recordings. With a few variations, the assessment was fairly similar to the author's evaluations. The evaluations confirmed that all students especially required improvements on intonation and a mixture of characters, emotions and musical expression.

Table 10. **Student Evaluation Card – Expert String Player 1 Before Mental Training**

	CRITERIA					
Student	**Musical text**	**Rhythm**	**Tone quality**	**Dynamics**	**Characters, emotions, musical expression mixture**	**Scores**
	Intonation, fingering	**Bow division**	**Sound points**	**Dynamic contrast**		
1	1	1	1	1	1	**5**
2	1	1	2	1	1	**6**
3	1	1	2	1	1	**6**
4	1	2	1	2	1	**7**
5	1	1	1	1	1	**5**
6	1	1	2	1	1	**6**
7	1	2	2	2	1	**7**
8	1	1	1	1	1	**5**
9	1	1	1	1	1	**5**

Table 11. **Student Evaluation Card – Expert String Player 2 Before Mental training**

	CRITERIA					
Student	**Musical text**	**Rhythm**	**Tone quality**	**Dynamics**	**Characters, emotions, musical expression mixture**	**Scores**
	Intonation, fingering	**Bow division**	**Sound points**	**Dynamic contrast**		
1	1	1	1	1	1	5
2	1	1	2	1	1	6
3	1	2	1	1	1	6
4	1	1	1	1	1	5
5	1	1	1	1	1	5
6	1	2	2	1	1	7
7	1	2	2	2	1	8
8	1	1	1	1	1	5
9	1	1	1	1	1	5

This initial evaluation of student violin playing would also seem, at least on the surface, to illustrate the commonly held belief that further techniques cannot and perhaps should not be developed if the intonation and pitch is not accurate. It is indeed interesting in these baseline measurements that intonation, dynamic contrasts, and overall musical expression scored some of the lowest scores. However, whilst it is undoubtedly the case that the musical work may not be recognisable if the pitches are incorrect, analysis of the literature in this dissertation has indicated that concentrating purely on the concept of intonation by the teacher in lessons could create external pressures that can lead to stress-induced tensions in the hands and ultimately student inability to adjust a note to its correct pitch, even if the player has the correct mental image of the pitch. Thus, these measurements equally indicate that a more holistic approach could be taken to the improvement of intonation; that it could be addressed together with the musical and technical aspects of playing. Indeed, it is these additional aspects that could increase relevance for the student and involve a larger network of association, which has been identified in the literature in educational neuroscience as being essential during the process of learning.

On a different level – namely that of purely identifying the current state of student auditory-motor connections of an individual violinist – accurate measurement of intonation is an indicator of the current level of their auditory-motor connections. As the literature in neuroscience has shown, the connection of imagined sound to the movement required to achieve that sound is highly important. Thus, accurate evaluation of intonation in scientific research could indeed indicate and help identify the development of these auditory-motor connections.

Baseline Evaluations of Intonation and Tempo – data collated from analysis using computer programme *Melodyne 4* (January 2016)

Student 1 – This student had completed five years at music school with a different pedagogue before deciding to learn the violin solely in the specialist music primary school. This was the second year of study on the violin in this particular school. She played a three-quarter size violin.

This student had been presented with a new etude in the middle of December 2015 and had played the etude in the lesson situation at that time. The student had heard the pedagogue play this etude in December and the student had played through the etude herself at that time. Also at that time, the piano had been used as an instrument to help with correcting incorrect notes played by the student. This is a method commonly carried out in violin lessons and does not represent any part of mental training. The etude had also been played through once in January 2016 in the previous lesson. This measurement was taken a week later and consisted of the first 30 notes of etude op. 45. No 47 by Franz Wohlfahrt (see Fig. 34). As can be seen from the excerpt, the etude requires the left hand to play in two positions – 1st position for the first five notes and 3rd position for the remainder of the excerpt.

Figure 34. **Excerpt of etude played by student 1** (Wohlfahrt, 1936, 23)

Each note was measured in *melodyne 4* and compared against the fingers and positions used (see Table 12), after which the range of intonation was analysed.

Table 12. **Intonation in cents – student 1**

Position	**1st position**					**3rd position**																								
Fingers	2	3	0	1	2	1	2	3	2	3	2	1	2	3	4	2	3	4	1	2	3	4	1	2	3	2	1	2	3	4
Notes	Bb3	C4	D4	Eb4	F4	G4	A4	Bb4	A4	Bb4	A4	G4	A4	Bb	C5	A4	Bb4	C5	D5	Eb5	F5	G5	A5	Bb5	C6	Bb5	A5	Bb5	C6	D6
Intonation (measured in cents)	27	14	3	23	29	−10	4	−3	−11	−4	−8	−10	7	−19	−100	4	−1	1	−15	121	−13	−36	−11	76	−9	106	−9	103	−5	8

When comparing the note played to the finger used, it is possible to see that in 3rd position, the student is using the same finger spacing that is generally used in 1st position in a major key – such as A major, where there is a full tone between fingers 1 and 2 (B to C*sharp*) and a semitone between fingers 2 and 3 (C*sharp* and D). This key is often used with students at the beginning of studies. So, in 3rd position the student is creating a large gap between fingers one and two and a small gap between fingers two and three, which actually works relatively well in on the D string in 3rd position in B*flat* major (G = 1st finger, A = 2nd finger [= full tone between fingers 1 and 2], B*flat* = 3rd finger [= semitone between fingers 2 and 3]), but on the A string, there needs to be a semitone between fingers 1 and 2, since the notes are D and E*flat,* and the student continues to play a full tone – i.e. there is a large gap between fingers 1 and 2. The second finger, therefore, plays a semitone too high – E*natural*, rather than E*flat*. Interestingly, the next two notes are played by the student a little too low, which may signify that the student has heard that something does not sound correct and tries to adjust the following notes, rather than adjusting the note that was incorrect. These observations may help to illustrate an issue with the connection of the auditory and motor imagery. It may illustrate that the student is either not correctly pre-hearing the note, or that it is being correctly pre-heard and the hand is too tense to be able to adjust the incorrect note. Additionally, it seems that the habit gained in first position of finger placement is stronger than the connection between auditory and motor systems. The uncertainty of shifting to and playing in a new position may indeed have added to tension in the left hand, though this student had played in third position before.

So, a problem that can be detected here is that motor habits are perhaps stronger than auditory feedforward and feedback processes, especially when there is an aspect of uncertainty – in this case, playing in a higher position.

The ranges of the pitch are shown graphically in figure 35 and help to illustrate that the intonation falls below and high above equal temperament. It is also well outside the criteria devised for the ideal range of intonation (see Fig. 35).

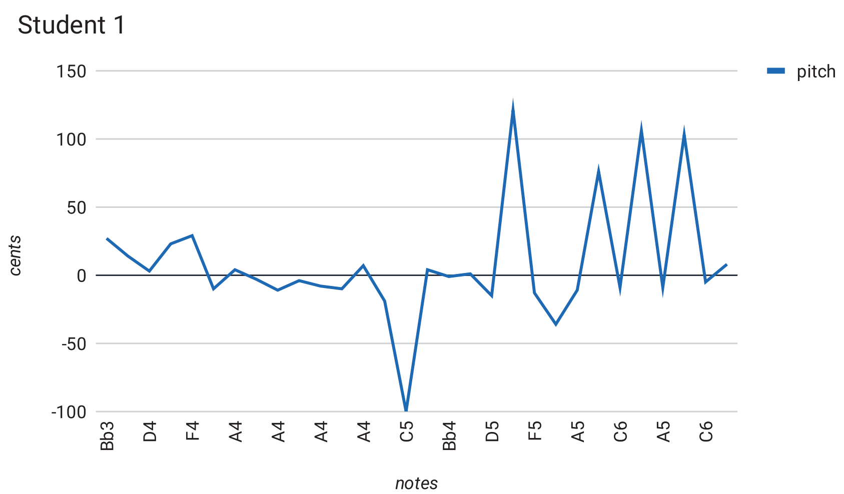


Figure 35. **Intonation of student 1**

Table 13 shows the overall range of the intonation plus the interquartile range, which helps to calculate the range of intonation of the notes that are not completely incorrect in pitch and to disregard the notes that are a semitone or more too high or too low. In this measurement, it is possible to see that the intonation is generally within the norms of intonation achieved by professionals. However, though this may be statistically significant, it may not help to identify the issues the student has with technical and auditory components. This is because the finger placements, and therefore also the sound produced, were correct on the D string in 3rd position, perhaps not because the student had understood the auditory requirements of the notes, but because the finger placements in 3rd position on the D string require similar distances as the finger placements in 1st position, and perhaps not correct because.

Table 13. **Student 1 intonational range**

Student 1	Measurements in cents
Minimum	−100
Maximum	121
Overall range	221
Interquartile range	22.5

Tempo. Here, each note was analysed for evenness of tempo. The tempo was set by the student at the beginning to a quaver being equal to 72 to 73 beats per minute (see Fig. 36). Interestingly, this analysis revealed that before a change of position the tempo slowed down considerably. This occurred on the note prior to the position change and also there was a silent gap shown in figure 32 as a fermata. In addition, the note in the new position is played more slowly than the following notes. (The note in the new position is highlighted by a square and the notes that are played on adjacent strings are highlighted with circles in figure 36.)

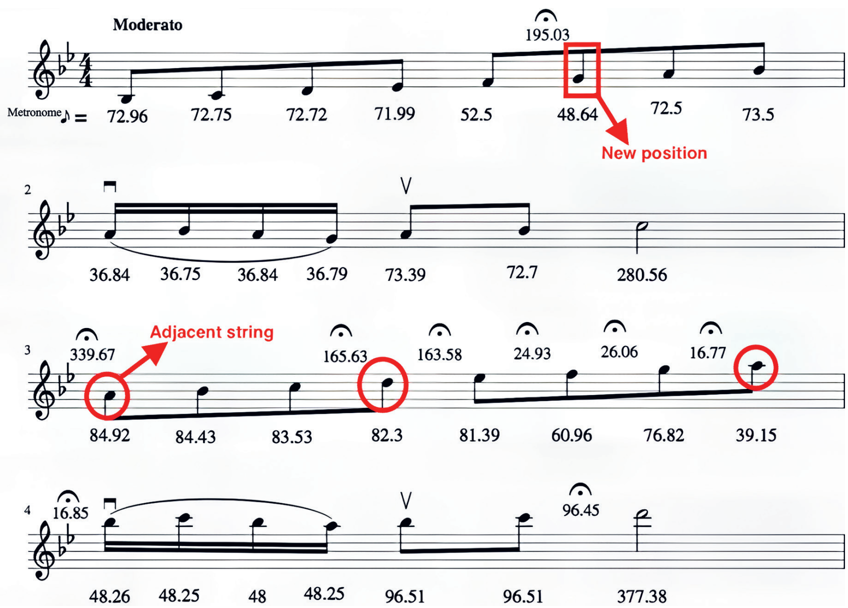


Figure 36. **Tempo of musical excerpt played by student 1.**

The number of pauses taken by the student in her reading of this etude could be considered significant. Since they were taken immediately preceding shifts, on notes preceding shifts and before notes that were situated on adjacent strings, it could indicate that thought processes were occurring, or rather that there were some uncertainties in the thought processes that preceded these. This seems to be one of the main aspects that needs to be addressed. An indication of improvement with tempo with this student would be the reduction in the number of pauses or fermatas between shifts, a speeding up of the semiquavers and lengthening of the longer notes.

Dynamics. Since there were no dynamic markings in this etude, the student did not attempt to show any contrasts of dynamics. However, the volume of playing was measured to be 23.5 dB. This will be a useful measurement for comparison with future measurements. Table 14 shows the overall measurements for student 1 (see Table 14).

Table 14. **Summary of baseline measurements for student 1**

Intonation		**Tempo Range**
		142.58
Student 1	**Measurements in cents**	**Average Tempo**
		40.97
Minimum	−100	**Number of fermatas**
Maximum	121	7
Overall range	221	

Student 2 – This student was in the fourth year, had studied the violin in the specialist music primary school for each of those years and played a half size violin when these baseline measurements occurred. This student had also been given an etude at the end of December 2015 and the measurement occurred at the beginning of January 2016. The first 20 notes were measured from the beginning of an etude composed by Franz Wohlfahrt Op. 74, No. 5 (see appendix 4).

The etude is in first position but includes some chromatic notes. The translation of data of the student's intonation from *Melodyne 4* can be seen in Table 15, as can the note labels and the left and fingers used (see Table 15).

Table 15. **Intonation in cents – student 2**

Position	**1st Position**																			
Fingers	1	3	2	0	2	1	3	2	4	3	1	3	2	1	3	2	0	2	3	2
Notes	A3	C4	F4	A4	C5	F5	A5	G#5	Bb5	A5	F4	D5	C5	B5	D5	C5	A4	F4	C4	B
Intonation	−18	−21	38	8	17	69	−33	−59	16	−68	187	−55	−15	132	−45	−5	5	13	−46	−85

Here, it can be seen that the student is perhaps aware that the finger placements in this etude need to differ from the A major position, since there seems to be an over-compensation – that the second finger is often too low – and especially when the second finger is actually meant to be in a high position, as in the case of the G*sharp* (2nd finger on the E string). This is −59 cents too low – more than a quarter of a tone. This seems to indicate that the student is aware that different finger placements are involved, but again is not aware of the precise sound that should be produced. In addition, the student has not noticed the need for a different, lower, 1st finger placement, from that of the A major position, with which learning often starts. This increases the range of intonation (see Fig. 37 and Table 16).

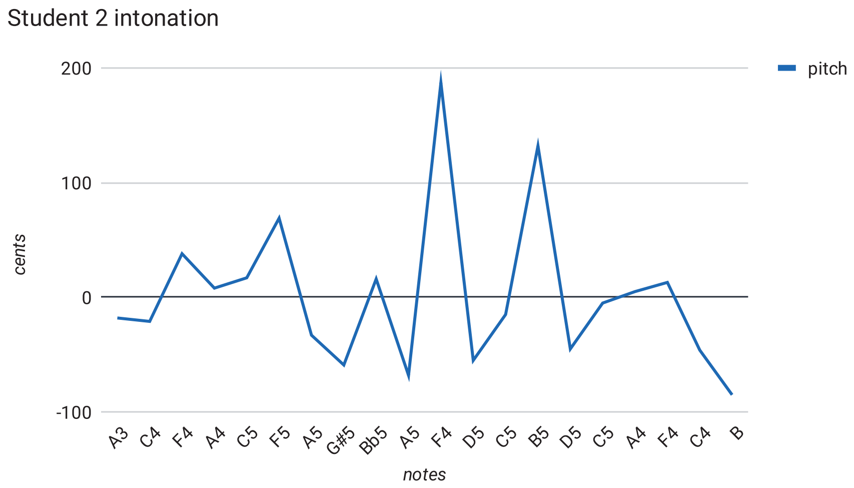


Figure 37. **Intonation of student 2**

Table 16. **Range of intonation, student 2**

Student 2	**Measurements in cents**
Minimum	−85
Maximum	187
Overall range	272
Interquartile range	61.25

Tempo. This student had uneven tempo and created fermatas at the change of strings. Also, fermatas were created before the notes that had accidentals attached to them. This showed that the student was thinking about where the fingers should be placed. However, since the notes after the pauses were not corrected, it may indicate that the student was not actually aware of the required sound of the note. This is assumed, specifically, since the student's posture and left-hand technique were fairly well placed – so there should have been no difficulties in adjustment. Indeed, an overall observation of this student in the past, is that when the concept of the note is correct, the student immediately corrects the pitch.

Probably because of the uncertainties of pitch with this etude, therefore, the tempo had a range of 69.97 (see Table 17) and rarely kept to the pulse set at the beginning of 61 BPM.

Dynamics. Again, this etude did not have any dynamics marked in the score. The general volume of playing was measured to be –20.4 dB.

General observations. This student has a natural tendency to verbalise everything she will be doing before she actually carries out the action. This is something that has been observed since the first year of study. She also comments verbally on what she has just played and what needs to be changed. In many ways, she verbalises some of the mental processes outlined in this dissertation: feedforward and feedback in particular.

Table 17. **Summary of baseline measurements of student 2**

Intonation		**Tempo Range**
Student 2	**Measurements in cents**	69.97
Minimum	–85	**Average Tempo**
Maximum	187	44.76
Overall range	272	**Number of fermatas**
Interquartile range	61.25	10

Student 3 – This student was in the third year of studies at the specialist music primary school and had played the violin for each of those years. This student chose to play a scale of D major, 2 octaves, spanning two positions: 1st position and 3rd position. Again, the tempo slowed down before and after shifting to a new position and there was a wide range of intonation (see Table 18), especially after shifting to a new position. The overall range spanned nearly two semitones (195 cents). The interquartile range, however, was just 41.5 cents (see Table 18), which means that the notes that were not completely wrong were within a quarter tone of their needed intonation. Whilst dynamic change was not necessary for the playing of a scale, the volume at which the student played was analysed (–21.8 dB).

Table 18. **Summary of baseline measurements of student 3**

Intonation (cents)		**Tempo Range (BPM)**
Student 3	**Measurements in cents**	85.74
Minimum	–43	**Average Tempo**
Maximum	152	54
Overall range	195	**Number of fermatas**
Interquartile range	41.5	7

Student 4 – This student was in her 5th year of study at school, but in the 4th year of violin playing, having started in her 2nd year. She played a three-quarter sized violin. The student had a only moderate sense of pitch, but was very keen to learn all aspects of violin playing. The study spanned two positions: first and third. There were some uncertainties of pitch in third position. The overall range of intonation was 75 cents, and the interquartile range was 40 cents (see Table 19). There were no long breaks in the playing, which is reflected in the zero number of fermatas in this measurement. This student played a Franz Wohlfahrt etude Op. 74, No. 32.

Table 19. **Summary of baseline measurements of student 4**

Intonation		Tempo Range
Student 4	**Measurements in cents**	70.80
Minimum	−16	**Average Tempo**
Maximum	15	50.62
Overall range	75	**Number of fermatas**
Interquartile range	40	0

Student 5 – This student was in her 3rd year of study at the beginning of this research and had played the violin since the 1st year at school. A quarter-size violin was played throughout the duration of this research. It is necessary to note that this student had general muscular coordination issues which were not only confined to the violin lesson. From the very beginning of studies, there were also coordination issues with violin playing, being unable, at first, to coordinate the two hands and also there were difficulties with timing a sound so that it would sound together with another instrument, such as the piano. In addition, the student was unable to repeat a sound by singing, having first heard it played on the piano or the violin. These issues were not helped by the fact that the student had an obvious worry about the time, continually asking before the lesson when the lesson would start, and also asking throughout the lesson when the lesson would finish. Learning the violin in the traditional manner of accompanying the student on the piano only seemed to interest the student in the piano. The student seemed unable to understand the link between a sound played on the piano and the sound required on the violin. However, the student seemed to want to copy movements, over which she did not seem to have a great deal of control. A connection to the research on mirror neurons seemed apparent.

This student played the first three bars of an etude by Franz Wohlfahrt Op.45, No 33. Table 20 summarises the data analysed from this student (see Table 20).

Table 20. **Summary of baseline measurements for student 5**

Intonation		**Tempo Range**
Student 5	**Measurements in cents**	115.77
Minimum	−272	**Average Tempo**
Maximum	4	73.20
Overall range	276	**Number of Fermatas**
Interquartile range	38	0

Student 6 – This student was in the third year at school, but only began playing the violin in second year. This measurement, therefore, took place in the student's second year of violin studies. This student had displayed some difficulties in concentration. The violin posture was not secure yet secure and there were difficulties relating a sound that could be fairly easily imitated with the voice, with the movement required to produce that sound on the violin.

This student had chosen to play a scale for this first measurement – D major, two octaves. During the playing in this measurement, the student needed to be prompted, as incorrect positions and fingers were being used. The playing, therefore, was not entirely independent. Additionally, this affected the rhythm and tempo (see Table 21).

Table 21. **Summary of baseline measurements for student 6**

Intonation		**Tempo Range**
Student 6	**Measurements in cents**	115.77
Minimum	−89	**Average Tempo**
Maximum	204	73.20
Overall range	293	**Number of Fermatas**
Interquartile range	43	2

Student 7 – This student was in the third year at school and in the third year of learning the violin. This pupil has good concentration and a relatively good sense of pitch. There were no notes in this first measurement that were pitched a lot more than a half a semitone too high or too low: the highest was 48 cents and the lowest −55 cents, with an overall range of 103. The interquartile range showed that many of the notes were played within the range required (see Table 22).

Table 22. **Summary of baseline measurements for student 7**

Intonation		**Tempo Range**
Student 7	**Measurements in cents**	22.68
Minimum	−55	**Average Tempo**
Maximum	48	62.08
Overall range	103	**Number of fermatas**
Interquartile range	31	0

Student 8 – This student was in the third year of study in the school and the third year of playing the violin. This student was very keen to play, though found some difficulties in singing a note heard on the piano, which may indicate that the inner ear needed to be developed more. There were also some posture issues that needed improvement – such as the posture of the left hand and the bow hold needed improving. Whole body posture was mostly good.

The student chose to play a scale of D major, two octaves for this first measurement. In this first measurement, the student was glancing at the teacher – as if looking for confirmation of the intonation. Since the teacher responded slightly by occasionally nodding or humming a note, the intonation might be a little better than had the teacher kept completely quiet. This may need to be taken into consideration later when comparing results after mental training.

The overall range of the intonation spanned 145 cents, the interquartile range being 59.5 cents (see Table 23), but still outside of the boundaries identified in this dissertation.

Table 23. **Summary of baseline measurements for student 8**

Intonation		**Tempo Range**
Student 8	**Measurements in cents**	130.96
Minimum	−76	**Average Tempo**
Maximum	69	50.94
Overall range	145	**Number of fermatas**
Interquartile range	59.5	10

Student 9 – This student was in the fourth class at school, but this was the first year of violin studies. Before the violin she had played the piano. The student had chosen to play *Song of the Wind* from the Suzuki method Book 1 for this measurement. Whilst the student seemed to have a fairly good sense of pitch for the beginning stages of playing the violin, she had some issues with tone production, mostly related to uncertainties in posture, often encountered at the beginning of studies, but this was quite pronounced with this student. Additionally, this student started the learning process with a fair amount of tension in the hands, which may have stemmed from a number of personal and/or school and home environmental issues.

The student often feared that she would be left behind by her friends – the lessons occurred on a Friday afternoon after school lessons had finished – and would frequently become emotional about this. Having almost excluded this student's playing from the research, a decision was however made to include it. It would be valuable to identify whether mental training could help in the pedagogical situation with students from differing backgrounds and circumstances; whether it could also help with creating a calm attitude towards violin playing, perhaps despite the opposite occurring elsewhere in the school environment.

The results of the baseline measurements are below. Interestingly, in analysing the results, it became apparent that repeated notes had differing intonation. This may be accounted for by the wrong use of the bow – that it was too heavy on the string, for instance, but could also be a symptom of a different problem: that instead of being held in the same position, that the finger was being placed again for each note – as a pianist would do for playing repeated note. This had not been noticed by the pedagogue at the time of measuring the musical excerpt, since micro movements are sometimes difficult to detect, but it could certainly be ascertained from the analysis of the recording.

The baseline measurements (see Table 24) perhaps also reflect the technical and emotional observations mentioned above. The overall range (219 cents) and the interquartile range (141 cents) indicate that the intonation needs to be improved. Additionally, the tempo and pulse were difficult to calculate, since the student lost her place in the music altogether after two bars. The measurements therefore refer to the first two bars of the excerpt, where the tempo range was 26.57 BPM.

Table 24. **Summary of baseline measurements for student 9**

Intonation		**Tempo Range (BPM)**
Student 9	**Measurements in cents**	26.57
Minimum	−78	**Average Tempo**
Maximum	141	44.19
Overall range	219	**Number of fermatas**
Interquartile range	141	0

General observations and conclusions

When analysing the results of the baseline measurements, it is possible to identify that the ranges of the students' intonations were indeed greater than that of the professional violinists; that an improvement in intonation would be indicated by a reduction in range. A Shapiro-Wilk test was conducted on the data generated by the students' intonations, to provide an additional measure to detect change pre- versus post- mental training.

Table 25. **Ranges of student intonations in baseline measurements**

Student	1	2	3	4	5	6	7	8	9
Minimum (cents)	−100	−85	−43	−16	−400	−89	−44	−76	−78
Maximum (cents)	121	187	152	59	4	204	48	69	141
Range (cents)	221	272	195	75	404	293	92	145	219
Mean	8.73	1.75	17.77	18.95	−139.75	20.07	4.43	−24.81	3.10
Std. Deviation	43.626	66.467	52.563	23.434	166.233	61.594	25.789	33.297	79.601
Shapiro–Wilk P value	0.000	0.018	0.000	0.143	0.003	0.001	0.858	0.102	0.141

Baseline Measurements of Tempo (see Table 25) revealed that students' range of tempos varied and, apart from students 7 and 9, ranges were much greater than that of a professional violinist. Student hesitations were noted: gaps in the musical pulse, where students were taking time to think about the next note. Four out of nine students were able to play without hesitations (see Table 26). Hesitations did not seem to correlate with the evenness/range of tempo, except with students 7 and 9, who displayed a narrower range and fewer tempo fluctuations. The measurements suggest that students needed to reduce both their number of hesitations and range of tempo.

Table 26. **Baseline measurements of the ranges of students' tempos**

Student	1	2	3	4	5	6	7	8	9
Tempo Range (BPM)	142.58	84.44	114.1	72.49	115.77	60.57	22.68	135.78	26.57
Average Tempo (BPM)	44.69	44.76	50.15	50.62	73.20	35.11	62.08	48.57	44.19
Hesitations	7	10	7	0	0	2	0	10	0

The baseline measurements provided by the students' playing outlined areas which needed to especially be considered when designing and realising a mental training system. It was noticeable in the lessons leading up to these measurements, that students were very aware of the examples and demonstrations given in lessons, sometimes trying to imitate the teacher's actions, even wishing to play a note on the piano to give an example of correct intonation, if the teacher had first done so in the lesson. When the teacher gave an example on the violin, the students appeared more eager to try and find the note on the violin. Other common observations were that students seemed to want to rely on the teacher's opinions, seeking confirmation or refutation from the teacher of their intonation. Since ideally, a student should be helped to be self-reliant, this would seem to be an important issue that could be addressed in a mental training system.

To effectively capture the current state of a student's enthusiasm and self-actualisation during these baseline measurements, the observation table depicting student interest, physical, psychological, and self-actualisation was completed according to the criteria and indicators (see chapter 1.5.). Scores were allocated to each criterion, with a 'high' level receiving 3 points, a 'medium' level earning 2 points, and a 'low' level awarded 1 point. The maximum overall score attainable was 24 points, reflecting the cumulative evaluation across all criteria.

Table 27. **Student Interest, Physical, Psychological and Self-Actualisation Observation Table, baseline measurements**

Student No.	Willingness to create personally relevant mental imagery	Independent Use of Mental training	Punctual attendance of lessons	Willingness to arrange extra lessons	Willingness to participate in group activities	Eagerness to perform in front of others	Positive attitude towards challenges	Regular Practice Habits	Overall Enthusiasm (Total)
1	2	0	2	1	1	0	1	1	8
2	1	0	2	2	2	1	2	2	12
3	1	0	3	2	2	1	2	1	12
4	1	0	3	2	1	1	2	2	11
5	1	0	2	2	1	1	2	2	11
6	2	0	2	1	2	1	2	1	11
7	2	0	3	3	3	2	2	2	17
8	1	0	3	2	2	2	2	1	13
9	1	0	1	1	1	0	1	1	6

Based on the results of the baseline measurements shown above (see Table 27), it is evident that the students varied in their levels of enthusiasm and engagement in learning the violin. For the criterion "Willingness to create personally relevant mental imagery" most students scored a "low" (1 point), indicating that they rarely created their own imagery without prompting. However, it should be noted that the intangible nature of mental imagery means that it is possible that students were creating the imagery without sharing with the pedagogue. However, it is interesting to note that there was some level of detectable independent mental imagery use in the form of similes, metaphors for musical interpretation, as well as some evidence that students were eager to create a "map" of the structure of the piece, which acted as a strategy for memorisation – an aspect that had been noted within the literature reviewed in this dissertation.

The criterion "Independent use of mental training" was not applicable at this early stage of the research, since mental training had not yet been introduced. For the "Punctual attendance of lessons" criterion, most students scored a "medium" (2 points) or a "high" (3 points), suggesting that students generally recognised the importance of attending violin lessons on time. The "Willingness to arrange extra lessons" criterion received varied scores, with some showing a higher willingness to arrange extra lessons (scored “2” or “3”) and others showing a lower willingness (scored “1”). This indicates differing levels of motivation and commitment to investing additional time and effort into their violin learning. For “Willingness to participate in group activities” most students scored a “medium” (2 points) or a “high” (3 points), indicating their willingness to engage in collaborative activities with their peers. This suggests a positive inclination towards group-based learning experiences. The “Eagerness to perform in front of others” criterion showed varied scores across students, suggesting different levels of comfort and confidence when it comes to performing in front of others. Some students exhibited a higher level of eagerness (scored “2” or “3”), while others displayed a lower eagerness (scored “1”). For “Positive attitude towards challenges” many students received scores indicating a positive attitude towards challenges (scored “1,” “2,” or “3”). This suggests a general inclination towards maintaining an optimistic approach when facing difficulties in their violin learning, but that this could still be improved. For the “Regular practice habits”, students displayed varying levels of regular practice habits, suggesting that this could be an aspect that requires further attention.

Other specific issues that were revealed during the process of conducting the baseline measurements included:

- The fact that students hesitated when faced with a less familiar action.
- That the students would resort to motor-related habits, rather than react to the sound they were producing on their instruments, especially in moments of uncertainty.
- That the uncertainty about intonation also seemed to correlate with uneven tempo and inaccurate rhythms.
- Confusion about the sound being produced: that their own sound production sometimes initiated disappointment to the student that was visible to the teacher, and which also affected posture and attitude towards the instrument being held.
- The need for a clear and positive mental picture of sound, movement, and posture.
- That the feedforward and feedback mechanisms noted in the theoretical research are not often apparent in young learners and that this needs to be developed.
- That notion of ideal intonation and tempo is a concept that needs to be built and constructed mentally – that there a student needs a clear mental picture of the combination of sound and movement, so that uncertainties and reliance on external verification can be reduced.
- That the attainment of accurate intonation is more of a mental, rather than a purely physical concept.
- That the teacher’s actions, reactions, and emotions are mirrored by the student in the pedagogical process.
- That the students need to find comfort – both psychologically and physically to be able to gain a positive attitude towards learning in general and therefore also to playing the violin itself.

2.3. A System of Mental Training for the Improvement of the Skill of Violin Playing

From analysing the scientific literature on the processes involved in playing a musical instrument, from reviewing the literature on the processing of external sounds to the generation of ideal sounds in the inner ear and from observing the process and results of the baseline measurements in this study, a main challenge in playing the violin would seem to be connecting sound, both perceived and imagined, to the necessary movements required to produce those sounds. It involves reacting to those perceived sounds that have been produced on the instrument, and in response adjusting the imagery. That is, the mental model of the sound often needs to be adjusted after having had practical experience and experimentation of creating the sound. In essence, it concerns a direct connection of the inner thought of violin playing – of single or combined mental imageries – to the outer, physical world of musical performance. One of the main challenges therefore would seem to be the training of thinking and awareness of it: thinking about the sounds and movements connected to violin playing and also to make this process personally relevant to the student.

Yet this poses challenges, since many of the students beginning the violin have never observed or consciously listened to the instrument being played. The violin per se therefore may not yet be personally relevant, especially at the beginning of studies and the possible sounds the violin can produce may not have been internalised. And although the students participating in this research had already played the violin for at least a year, the instrument was, and for many still, a relatively recent phenomenon. Additionally, the short time experienced in the violin lesson in primary school lessons – just twenty minutes twice a week – places a limit to the opportunity for the introduction of the *culture* of violin playing. However, there is an opportunity for this introduction and for the student to gain experience of violin playing in the lesson and so the question would seem to be: how can this experience be effectively and purposefully built in the lesson? What are the aspects that can encourage and inspire the students to be interested in the instrument and help them to become involved in their learning process, so a lifelong interest in learning can be identified by the student and maintained independently? What components are necessary in the learning process for student creative experimentation, whilst at the same time learning and recreating skill which has been passed down through generations of violinists and through changing socio-cultural environments?

To address questions such as these, each exercise in this chapter forms a part of an envisaged mental training system which is designed to relate to the multi-disciplinary literature outlined in the theoretical part of this dissertation and also to the violin skill improvement model. Alongside the practical hierarchy of skills, the students develop their internal processes – a quasi-mental skill hierarchy that starts with perception, travels through alternation with the practical and arrives at independent imagination – the formation of a mental model – that can then be experimented with practically, tested, reflected upon and, in response, then adjusted independently by the student (see Fig. 38). So, rather than the need for the students to initially produce mental imagery of the sound and movement, as in mental training with already-trained practitioners, the students can first perceive it – listen to it and watch it. Then, they can alternate and combine this perception with their own action, rather than alternate an action with pure mental imagery.

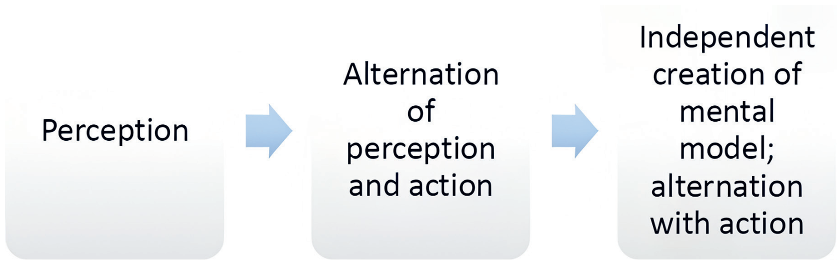


Figure 38. **The process of the student formation of a mental model**

Thus, the exercises that form this mental training system were organised into three stages that assist in the development of this process – the process of creating an independent mental model of the piece being worked upon, along with the development of violin playing skill, and which follows the organisation and sequence of the violin playing skill improvement model:

1) Musical concepts and content – the musical text and its concepts (which can also include some of the following two stages).
2) Posture, rhythm, pitch and fingering (which can also include aspects from stage 1).
3) Tone quality, musical expression, dynamics, characters

Exercise 1, 2, 3, 4, 8, 9, and 13: For the gaining of overall musical concepts of the piece and the musical content, including cognitive concepts of fingering, intonation and rhythm and can include some postural aspects.

Exercises 2, 3, 4, 10, 11, 12, 13, 14, 15: for developing concepts of posture, rhythm, intonation and the combined imagery of sound and movement and can include some musical, conceptual aspects.

Exercises 5, 6, 7, 9, 12 and 13: For developing musical expression and independence – self-awareness of skill (see Fig. 39). As can be seen some exercises overlap in their concepts and functions. All are founded upon the approach, which essentially becomes the combined approach taken by the teacher and student (see chapter 1.3).

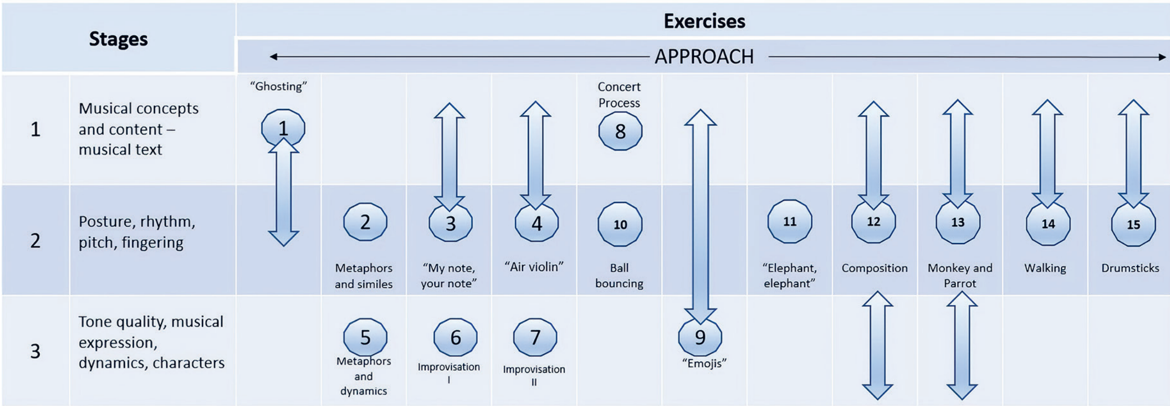


Figure 39. **Organisation of exercises into three stages: a system of mental training**

Approach to the pedagogical process with mental training. Whilst the concept of mental training seems, at least on the surface, to be concerned with the pure gaining of skills, one of the most important points of concern with mental training in the pedagogical process is that of approach. Additionally, the concept of pedagogical approach is neglected in most violin method books.

To understand how this is important, it is useful to understand that mental training for already-trained practitioners starts at a later stage, when the imagery can be based upon previous experience. Mental training with students seeks to help the awareness of mental imagery, and also the associated skill, plus also help create a learning process whereby mental imagery will be enjoyable. Additionally, considering approaches need to be considered, so that traumas are not formed and mental imagery of playing will not be painful for the student. A learning environment needs to be created whereby the students are not dependent on the teacher's instructions and wishes but feel independent and enjoy the process of gaining awareness of the processes involved in violin playing. Indeed, the teacher needs to be aware of the age and developmental level of the student and be sensitive enough to adjust and develop each exercise together with the student; to be congruent and open to new suggestions and directions that the collaborative process may reveal.

The relationship between a student and their violin teacher, or pedagogue, is also crucial in shaping the student's understanding and connection to the rich tradition of violin playing. Through collaboration with their teacher, students can learn the techniques and attitudes necessary to excel as a musician. In fact, many successful violinists credit their early teachers as major influences on their development as musicians, such as famous soloist Anne-Sophie Mutter who cites her first violin teacher as her role model (Mutter, 2015). Research on mirror neurons and theories of "modelling" in social learning, as proposed by Albert Bandura (see Bandura, 1977), suggest that it is important for the teacher to maintain a positive attitude and emotional demeanour in order to foster a similar attitude in the student.

Additionally, one of the most important moments in the violin lesson is the very beginning, whilst the student is taking the violin out of the case. As has been identified earlier in this dissertation (see chapter 1.3), it is before the actual learning takes place that warming-up the short term memory can occur. Asking the student questions about the previous lesson – what was learned, the topics covered, or if it is an early morning lesson, what was eaten for breakfast, not only helps to involve the short term memory necessary for learning, but also can help the student to participate and start the process of collaboration. Additionally, the information given at the beginning of the lesson can also be used in metaphors and visualisations later in the lesson situation. Playing a musical passage in the manner of thick porridge with syrup, as was perhaps eaten for breakfast, or comparing the ties and slurs in a musical phrase to addition signs in the previous mathematics lesson earlier in the day, can add personal relevance to the learning process and also, according to the theoretical literature in neuroscience, build upon existing neural structures – activating multiple neural associations and networks – and so help the learner to remember the new information being learnt. In addition to this, a lesson structure can be developed collaboratively at the beginning of the lesson by asking the student to create a list of the tasks that need to be worked upon in that session. This helps the student "build" their lesson environment and could reduce stress caused by cognitive uncertainty identified in the neuroscientific literature.

Introducing the components of violin playing. It is on this collaborative basis in the pedagogical process, that the following hierarchy of skills can be introduced (see Fig. 40). This hierarchy, developed especially for this research, outlines the techniques involved in violin playing, and forms the foundation of the violin skill improvement model (see Fig. 25). The students can be introduced to the concept that the lesson, or the repertoire which will be worked upon in the lesson, can be based on this structure, and which exact components from this structure are to be included in the lesson. It can also be explained to them that this model essentially represents their journey to the concert hall – that when we are sure that all these components have been worked upon to a high standard, then the best place to be is in the concert hall.

Figure 40. **The hierarchy of musical-technical skills viewed in the lesson situation** (Vilnite)

Being based on the concept that it is not possible to effectively multi-task, and that each component of a skill needs to be first learnt separately, the students are told that each component will be worked on separately; and that for each repetition of a musical phrase, a different component in the hierarchy can be concentrated on. Additionally, the students can be encouraged to continue to work themselves on each component separately during their independent practice repetitions. This hierarchy essentially becomes a checklist for both the teacher and the student – or at least helps the student to gain a basic concept of the ideas connected to the concert preparation process, and indeed the concepts that can be given attention during further, independent practice.

After this, and according to the violin playing skill improvement model developed for this dissertation (see chapter 1.5 and Fig. 25), the student is given the time to play through the musical work being learnt and/or may listen to the work being played by the teacher. Listening to the work on a mobile device is also recommended to the student when engaging in independent practice. These two stages – the conceptual studying of the hierarchy of skills and then the listening, or indeed, the practical experimentation can represent the first stage of the violin skill improvement model (see Fig. 25).

It is here that the students gain an awareness of the musical text and the musical and technical concepts connected to it. It would seem important to gain this general concept, regardless of the repertoire being learnt: whether it is an etude, a concerto, or simply a scale.

Additionally, depending on the mood or

After this introduction, or approach is deliberately taken by the teacher, the following exercises may be used.

Exercise 1: "Ghosting": For connecting movement with deliberate feedforward of sound and developing concepts of intonation and tone production

This exercise was created with the idea of training to be able to connect sound with movement and for training to be able to use the inner ear; to develop the concept of the ideal sound. Indeed, a student who has never heard how the notes sound, and how the musical notation looks for those sounds, will presumably not be able to produce the sound mentally. Since many mental training exercises used with already-trained practitioners depend on this aspect of mental rehearsal, this exercise could be considered as training for mental training as documented in literature that is presently available on the subject. The observational and listening aspect of this first exercise is inspired by the theory of mirror neurons and auditory mirror neurons mentioned earlier in this dissertation. The miming aspect of this exercise – that is, playing the exercise with the left hand only and without the bow – could also be considered as linking to aspects within the silent exercises in both G. Eberhardt's method (Eberhardt, 1910) and D. C. Dounis' first exercise (Dounis, 1925), where the player is presented with exercises to develop the physical aspect of playing. The present exercise, however, incorporates this silent aspect, but for a differing goal – that of connecting the physical movements to the ideal sound that those movements create. not only for technical exercises and individually however, but in collaboration with the teacher, so that the movements are connected to the ideal sound that those movements make.

In this current exercise, two to four bars from a musical work are chosen and the following steps are carried out:

1) The student plays the excerpt of music (the teacher listens, without commentary – in accordance with the theory on the pedagogue reducing verbal instructions);
2) The teacher asks the student to put the bow down on the table and hold the violin only in playing position.
3) The teacher asks the student to pay attention to posture, for which imagery can be used (see Exercise 2 below), to make sure that the left hand is being held correctly.
4) The student then puts the bow down and reads the music with the violin being held only.
5) The teacher then plays the excerpt whilst the student follows the music and fingers the excerpt – that is, the student places her fingers on the violin and follows the music as if she was playing the music herself, but the sound is being produced by the teacher's playing (see Fig. 41).
6) The teacher observes whether the student has understood which fingers and positions need to be used, and whether the excerpt needs to be repeated. If yes, then step five can be repeated.
7) The student then puts down the violin and takes only the bow.
8) The teacher then plays the excerpt again and the student reads the music and mimes with the bowing required in that excerpt (see Fig. 41).
9) The student plays the excerpt alone.
10) The teacher suggests playing in a certain character – perhaps in the character of a large person, or in the character of a large animal. The students are encouraged to create their own imagery.
11) The student plays again whilst keeping this imagery in mind.

Figure 41. **Steps 5 and 8 of exercise 1**

It is planned that this routine will help the student to consider the cognitive aspects of violin playing – which fingers are used where and in what position and also to consider the type of sound produced: its quality and production. It is envisaged that by not creating a sound, but listening to the correct sound whilst creating the movements for that sound, the student is working towards the auditory-motor connection of correct sounds and movements; that the perceived sound will help to produce an imagined one – the basis of feedforward processes in playing a musical instrument.

This exercise is designed to be carried out in the classroom situation, but can be continued by the student independently, if the teacher records the repertoire being worked upon on the student's mobile device or uploads a video or audio of the repertoire to an internet site that the student can easily access.

This exercise can be considered to connect to the theory on internalisation and on the literature that shows that mental rehearsal with movement is more successful than mental rehearsal without movement. It also follows the process laid out in the violin playing skill improvement model.

Exercise 2: Metaphors and Similes. Developing concepts of posture through imagery of abstract, but concepts that are familiar and personally relevant to the student

Imagery is developed together with the student to help with the concepts of posture. Examples are given here, but the imagery may be more effective if it is personally relevant to the student.

Bow hold. The frog of the bow could be compared to a television (or a computer screen), because of its similar shape; the two right-hand fingers that cover it, could be described as needing to be there, because you cannot watch the television and play the violin at the same time.

Scenarios for the placement of the fingers on the bow and thumb underneath it can be developed. For instance, in the Suzuki method, the thumb is placed on the metal part of the bow – the ferrule. Whilst this encourages a more open, relaxed hand position, the thumb often remains straight, instead of bent. To remedy this, imagery of a fish swimming up towards the top of a pond can be used. The pond is representative of the metal ferrule that must feel cooler to the students, than a thumb placed in the usual place on the wood of the bow. Meanwhile, imagery of two friends – the middle two fingers, held in front of the frog – can represent two friends sitting on a bench by the pond, watching the fish in the pond swimming. Another friend – the index finger – decides to walk away, whilst a little bird is sitting on a nearby branch – the little finger placed on top of the bow – listening to and watching the scene below.

Angle of fingers/hand on the bow and correct placement of thumb. Whilst turning the bow hair towards the player, which can be accompanied with a phrase, such as, "Let's examine the bow hair!" a face on the middle of the thumb can be imagined and accompanied by a phrase similar to, "Oh, look! Your thumb's happy / looking at you!"

Whole body posture. The whole body posture could be described as being inside a clock, where the left arm points to 10 o'clock and the nose of the player points to 11 or 12 o'clock.

In the gap between the left hand and the violin, a little bird could be imagined, or a rabbit in a rabbit-warren, who is listening to the violin. Similarly, the gap between the thumb and the bow could have an imagined bird, or something similar.

The imagery is developed together with the pupil, so that it is personally relevant and so that it links to concepts already experienced – thus building on the already developed neural structures.

Exercise 3: "My Note, Your Note": For rhythmic awareness

In this exercise, a musical phrase is chosen – four to sixteen bars, depending on the difficulty of the repertoire for the student, or indeed, the particular mood of the student on that day.

1) The phrase is divided between teacher and student: the student plays one note, the teacher plays the next.
2) The process is reversed, so that the teacher starts with the first note and the student plays the next (see Fig. 42).
3) The student plays the whole excerpt.
4) The excerpt is then split up into bars: e.g., the teacher plays the first bar, the student plays the next.
5) This process is then reversed.
6) The student then plays the whole excerpt again.

Figure 42. **Example of the alternation of teacher and student playing**

In addition to the rhythmic awareness that this exercise is designed to assist in, this exercise is also designed to develop the concept of the inner ear, so instead of playing the note the student listens to it. The exercise could also be later done without the teacher playing, but with the student alone – that is, independently creating aural/rhythmic mental imagery of the missing notes.

Exercise 4. "Air violin": For developing the independent awareness of the inner ear

In this exercise, the violin is not physically held at all. This exercise is designed to be carried out after initial playing has occurred in the lesson.

The student reads the music and plays the correct fingers against the thumb whilst singing the pitches of the music (see Fig. 43). This exercise is created with the idea of creating an awareness of the deliberate process of exteriorisation, developing a sense of mental rehearsal without the instrument. Additionally, it also connects to the research that cites movement with mental rehearsal being more successful than mental rehearsal alone.

Figure 43. **Example of the movement of the fingers and thumb**

Exercise 5. "Dynamics": For creating dynamic contrasts and characters

This exercise utilises indirect mental imagery: the use of metaphors.

1) The teacher discusses the concepts of dynamics, phrasing and characters in the music and gives examples of contrasts, both with imagery and with playing the violin.
2) The student is asked to create their own imagery to represent the characters heard.
3) The student is asked what characters they see as *piano* and *forte*.
4) The student is asked to think of those characters whilst creating piano and forte dynamics on the violin.
5) The student is encouraged to create their own scenarios connected to those characters.

This exercise is devised to develop an awareness of musical interpretation and, by creating their own metaphors and similes, to do so in a personally relevant manner.

Exercise 6. Improvisation 1: For awareness of polyphony and for confidence-building

This exercise was devised around a simple exercise on the A string (see Fig. 44), but can be used together with other exercises, such as those by H. Schradieck.

1) The student plays the exercise repeatedly and the teacher improvises.
2) The teacher plays the exercise, and the student improvises.

Figure 44. **A simple exercise on the A string**

This exercise is designed to build the confidence of the student; to let the student experiment. The student is told that everything they do is correct; mistakes are not possible. It also creates an interesting way to play a very basic – and perhaps usually also uninteresting – exercise that is necessary in the early stages of learning. It could also be used as a method for warming up after the initial verbal warm-up mentioned in the lesson plan.

Exercise 7. Improvisation 2: For developing awareness of musical characters, musical interpretation and different violin techniques

For this exercise a page from a comic, nature book or any picture is observed. It is envisaged that steps 4 and 5 can be used interchangeably, depending on the time constraints of the lesson or the mood of the student.

1) Teacher and student discuss the different elements of the picture – perhaps there are different animals, or perhaps an interesting landscape with hills or forests, for example. Maybe there could be some weather aspects – such as wind or rain.
2) The teacher asks the student to take their instrument to try and give a certain element in the picture a sound. The teacher may ask, "How would you create the feeling of rain?" or "What kinds of sounds could illustrate the animal in the picture?"
3) The student experiments with different effects. The teacher can help if the student asks, or be reminded of the different techniques they may already know, such as pizzicato, *sul ponticello* (playing on the bridge of the violin), glissandi, flautando, etc. The student is encouraged to develop different sounds for the different elements in the picture. (The student may "invent" tremolo or a combination of tremolo and glissando.) The student is encouraged by the teacher if there is some shyness – because everything they do is good: it's their improvisation; all "mistakes" are allowed.
4) Without revealing to the teacher, the student chooses a character in the picture and plays it to the teacher. The teacher needs to guess the character that is being portrayed. The teacher and pupil improvise at the same time, as if playing a duet. The teacher may introduce some different effects on the instrument.
5) The student can play alone – incorporating all the elements one after the other in the picture.

Exercise 8: Rehearsing the concert process

The goal of this exercise is to help the students in the classroom develop the concept that imagery can be used for mentally rehearsing the concert process – where students can imagine themselves playing at the concert hall – with all the actions of walking on the stage, smiling, regulating the music stand if necessary, remembering in which order the musical works are to be played. Then playing at least the beginnings of each piece through in the mind – complete with characters, emotions, stories and scenarios.

From the literature, it is important to remember that images and visualisations in the pedagogical process need to be kept to a positive nature, so that the student is encouraged to visualise positive concert and playing scenarios. The following exercise was designed for assisting students in the younger classes develop an awareness that the concert can be pre-planned and played through in the mind.

Developing imagery of the concert process – combination of action and imagery:

1) **Student and teacher exit the classroom and close the door.** Imagery of the time before entering the stage is developed: The teacher describes the situation that can occur before playing, and before entering the stage, including how to safely hold the violin in resting position (preferably under the right arm, so that one arm is free to hold on to any bannisters or open or close doors, etc).
2) **The teacher describes an imaginary scene of the stage and the circumstances that might precede the student's performance.** For instance, the student may need to wait for the previous performance to end before playing, so the teacher can ask the student to listen to ascertain whether there is anyone still playing.
3) **Teacher and student enter the classroom as if entering the stage**. The teacher asks the student to imagine the audience who are now clapping (the teacher may also clap to imitate the audience). In order to remind the student to bow, the teacher can ask, "What do we have to do when the audience is clapping?"
4) **The student prepares to play**. Still imagining the direction of the imaginary audience, the student can be prompted to stand so that the f-holes of the violin are facing the audience and in a location in which the student can still communicate with the accompanist.
5) **The student plays the work(s) in the same order as will be required in the concert/ exam.** If there are several works to be played, the student and teacher discuss what will happen in the gaps between the pieces: where the violin will rest and whether or not to bow to the audience, etc.
6) **The musical work(s) are played**. On completion, the student is asked what needs to be done on stage after playing. The student can be reminded to smile (or imagine smiling), to bow before exiting the imaginary stage, imagining the applause from the audience. Teacher and pupil again exit the classroom, imagining that they are exiting the stage.

7) **Analysis of aspects of this process.** Using positive language and after congratulating the student for completing the process, the teacher asks how the student feels and whether they feel that they have achieved what was planned; whether anything went better or worse than expected, or if anything took them by surprise, for instance.
8) **This whole exercise can be repeated until the student becomes comfortable with imaging the concert situation.** It is envisaged that the exercise will become a reference point for later mental rehearsal. The exercise can be repeated in subsequent lessons if necessary. (In a lesson plan this could be at the end of the lesson to recap on the day's work or near the beginning of the lesson to assist in captivating attention or adapting to the lesson environment)

Exercise 9: "Emojis." For developing musical characters and awareness of musical interpretation

It is envisaged that this exercise will not only help develop awareness of imagery musical interpretation, but also inspire the student to repeat their repertoire a few times for differing goals and purposes, thus developing the concept of "feed forward."

1) The student plays through a musical work, or a section of it.
2) The student draws five different "emojis" or faces showing emotions on sticky note paper.
3) The student arranges the pictures in an order on the music stand, not showing the teacher the order of the emotions.
4) The student plays again and the teacher guesses which emotion they are trying to portray.
5) Step four is repeated 5 times (or for as many times as there are emojis).
6) Teacher and pupil discuss the different musical effects explored and the different techniques employed to create them (see Fig. 45).

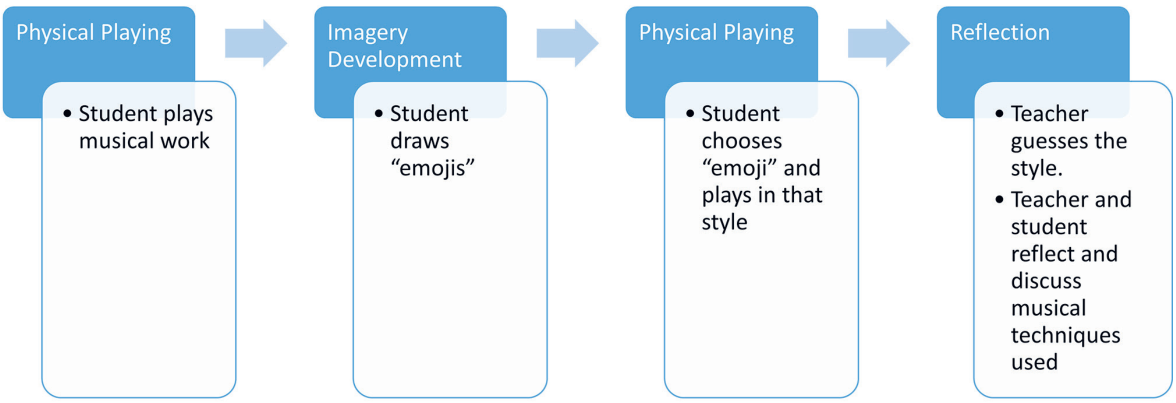


Figure 45. **The process of exercise 9**

Exercise 10: Bouncing ball and left hand pizzicato

To be carried out without the bow. This exercise was designed to practise deliberate feed-forward processes during a current action and is split into three levels.

Level 1, preparation:

1) Whilst holding the violin on the left shoulder and with the left hand in playing position, the student bounces a soft ball and catches it.
2) After successfully catching the ball, the teacher asks the student to play left-hand pizzicato on a specific string with a specific finger. (The teacher will vary the string and finger each time this step is repeated)
3) The student plays the left-hand pizzicato and bounces the ball again, after which stage 2 is repeated.

Level 2, personal goal setting:

1) Before bouncing the ball, the teacher asks the student to choose the string and finger for playing the left hand pizzicato.
2) Still with the violin on the left shoulder and left hand in playing position, the student bounces the ball with the right hand and catches it.
3) The student realises the goal of playing the left hand pizzicato.

Level 3, increased challenge:

1) The student is now asked to choose two strings and two fingers before bouncing and catching the ball (these can be played as double-stops or consecutively)
2) The student realises the goal set.
3) Repeat these steps until the student can set goals and achieve them with ease.

Exercise 11: "Elephant, Elephant." For developing concepts of tone production

The purpose of this exercise is to assist in the development of awareness of skill – particularly bow speed and arm weight – but also to introduce the concept of repetition and experimentation; to be able to work upon something and improve it with each repetition.

This exercise uses imagery to label the bow with three (imaginary) areas and assists in developing awareness of bow speed (see Fig. 46).

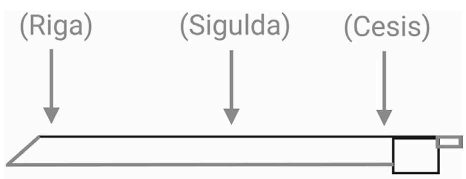


Figure 46. **The violin bow split into three areas**

1) Building the imagery. Because the bow is travelling, the teacher asks the student to imagine that a train (or car) is travelling from their home town "Cēsis" and shows the area of the bow by the frog (heel).

2) The student is asked to imagine where the train could travel to by the time the train reaches the tip of the bow (e. g. "Rīga")
3) The student is then asked which town is halfway between Cēsis and Rīga? (e. g. Sigulda).
4) The student is asked how many elephants are on the train from Cēsis to Rīga.
5) The student plays a "down bow"- a sound starting in Cēsis (by the heel of the bow) and travels with the bow (train) towards Rīga, whilst the teacher counts (aloud), "Elephant, Elephant, Elephant." One elephant is equal to one beat at 80 BPM. (The teacher observes the metronome, which is in silent mode, in order to count the beats accurately.) The imagery of an elephant is employed to give the idea of the feeling of weight in the hand and arm as the bow travels.
6) The teacher and pupil compare/discuss the number of elephants that have been counted.
7) The student now plays an "up bow" from Rīga to Cēsis (from the tip of the bow to the heel of the bow), whilst the teacher and pupil again count the number of Elephants.
8) The number of elephants are compared from both directions
9) The student is asked to now travel from Cēsis to Sigulda (starting on a down bow) and from Sigulda to Riga.
10) Analysis of results and repetition of exercise.

The number of elephants or beats can be noted in a table, for easier analysis by the student (see Fig. 47 below).

Bow Distributions	**No. of Elephants / Beats (♩ = 80)**	
	1st time	**2nd time**
Cesis – Riga (down-bow)		
Riga – Cesis (up-bow)		
Cesis – Sigulda (down-bow from heel to middle of bow)		
Sigulda – Riga (down-bow from middle of bow to tip)		
Riga – Sigulda (up-bow from tip to middle)		
Sigulda – Cesis (up-bow from middle to heel)		

Figure 47. **Bow distribution table for exercise 11**

Exercise 12: Melodic composition. For general development of awareness of notation, its associated sound and the feedforward processes of violin playing

For this exercise, a dice, altered to display the note names of the musical scale, a white-board with musical leger lines and a white-board marker is required. The student "builds" their own musical environment and is encouraged to begin to pre-hear pitches and imagine how to achieve them physically on the violin.

1) A treble clef is drawn on the whiteboard and a time signature.

2) The student throws the dice to create one to two bars of music (4 or 8 notes in 4/4) and writes each note as a crotchet.
3) Whilst writing the individual notes, the student is encouraged to sing the note name at the correct pitch (the teacher helps in this process) and imagine with which finger the note on the violin is produced.
4) After writing the notes, the student takes the violin and plays the pitches notated on the white board.
5) The white board can be turned upside down.
6) The student attempts to imagine how to play the newly transformed notes and their associated sound before playing them on their instrument, either against their finger and thumb, as in exercise 4, or on their instrument without the bow, as in exercise 1.

Exercise 13: Imitation and improvisation ("Monkey and Parrot") – to develop creative, feedforward processes and introduce new technical and musical concepts

The student is offered to pretend they are either a monkey or a parrot. (The teacher remembers that the monkey improvises and the parrot imitates)

1) The teacher (or student) improvises – approximately 8 notes, depending on the student skill level. (If the teacher improvises, then the teacher can include technical elements the teacher considers would be interesting for the student, or that will help the student develop a better technique)
2) The student (or teacher) imitates.
3) If the student's imitation is not accurate, the teacher asks if the student would like to hear the improvisation again, so they can try a second time, but no criticism is given.
4) The teacher and student change roles.
5) When the teacher imitates the student's playing, it needs to be played with a good sound and as artistically as possible.

Exercise 14: "Walking Pulse" – to inspire a feeling of internally generated pulse

Whilst the main purpose of this exercise is to develop an internally driven sense of pulse, it also serves to consolidate the text of the musical extract and encourages the student to work from memory.

1) The student plays through an except (4 to 8 bars) of a musical work.
2) The student decides (together with the teacher) on the required speed of the excerpt (according to the needs of the student).
3) Without the violin, the student walks at this tempo, so that each footstep represents a crotchet (or quaver, or sub-division, depending on the speed and time signature of the musical work), whilst imagining the pitches and sounds of the musical excerpt.
4) The student takes the violin and plays the violin whilst walking at the desired pulse and at the same speed as imagined in step 3.

Exercise 15: "Drumsticks" – to inspire internally-generated pulse and to develop concepts of musical text

For this exercise, two drumsticks are required. Designed for the purposeful development of the concept of pulse during and before the beginning of the music being played, this exercise also provides an opportunity for focused listening of a musical work, drawing attention to rhythmic nuances.

1) The student plays an excerpt of a musical work (4 to 8 bars, or more depending on the difficulty of the piece or learning stage of the student).
2) The student takes the drumsticks and is invited to "play the drums" or "be the metronome for the teacher." (The teacher demonstrates how to tap the drumsticks together to make a sound.)
3) The student takes the drumsticks, tries them out, and decides on the pulse. (The teacher can assist by singing/humming the melody of the musical excerpt.)
4) The student beats a whole bar in before the teacher plays the musical excerpt on the violin. The student continues to tap the drumsticks to the pulse during the teacher's playing.
5) The student and the teacher swap roles: the teacher now taps the pulse with the drumsticks and the student plays.
6) The student plays the musical except again on the violin without the drumsticks being tapped.

Commentary about the use of the exercises. It is not envisaged that every single one of the exercises is carried out in each of the students' lessons, but rather that they are chosen and adjusted to suit the individual needs and interests of the student. And although the combination of the exercises could be regarded as being part of a system of mental training that follows the organisation of the improvement model, each individual exercise could be regarded as a mini system in itself. Indeed, they are designed to explore different aspects of the same concept – that of connecting the idea of sound, its mental image, to the necessary movement to create that sound and to encourage the idea of experimenting with sound and movement imagery, so that the concepts of feedforward and feedback are introduced. However, the order that a musical work is worked upon should follow the sequence of the concepts in the violin skill improvement model: that musical concepts and content, followed by aspects of posture, intonation and rhythm. Exercises 10, 11 and 12 have been developed with the idea that they can also be used independently of repertoire being learnt, since they help to develop concepts central to mental training and therefore also assist students in building skill to learn future repertoire more effectively.

A table of the exercises and approaches discussed in this chapter, together with their connections to aspects identified in mental training and neuroscientific literature and which are congruent with both the hierarchy of skills and the violin skill improvement model are presented in Table 28:

Table 28. **Table of exercises and approaches**

Exercise routine / Approach	Intonation	Posture	Tone Production	Rhythm / Pulse	Musical Interpretation	Mental Process (cognitive) or purpose	Pedagogical aspect
Collaborative lesson planning and lesson introduction						Reduction of cognitive uncertainty. Feedforward of learning and musical aspects.	Collaboration, student goal setting and goal realisation
“Ghosting”	•		•	•		Mirror neurons, auditory perception, physical playing, development of feedforward and feedback, development of connections between auditory and motor networks	Attentive listening with action
“Elephant”		•	•	•		Creative mental imagery alternated with playing	Setting attainable goals, personal relevance, experimentation to gain self-awareness of skill
“My Note, Your Note”				•		Auditory perception, motor imagery, development of feedforward. Predictive rhythm / pulse / tempo development	Collaboration
Personalised metaphors and similes	•	•	•	•	•	Motor and Auditory Imagery	Personal relevance, experimentation with material

Exercise routine / Approach	Intonation	Posture	Tone Production	Rhythm / Pulse	Musical Interpretation	Mental Process (cognitive) or purpose	Pedagogical aspect
Air violin	•	•	•			Motor and Auditory Imagery, feedforward processes	Goal setting
“Concert Process”		•	•			Mental imagery	Goal setting
Emoji			•		•	“Online” mental imagery	Personal relevance, experimentation with material
Drumsticks			•	•		Predictive feedforward, internal sense of pulse development	Active/Attentive listening
Walking Pulse		•		•		Predictive feedforward	Student building self-awareness
“Bouncing Ball”		•				Feedforward processes	Goal setting
Improvisation – pictures			•		•	Feedforward processes	Building own environment
Imagery before shifting	•	•				Feedforward processes	Goal setting
Composition-dice	•		•		•	Feedforward processes, connection of auditory and motor processes	Building own environment,
“Parrot and Monkey”	•			•		Feedforward processes	Building own environment/ experimentation

Overall, the development of mental skills through the mental training system aims to develop:

- Concepts of sound quality, intonation and dynamics.
- Connection of auditory and motoric skill.
- Combination of perception and imagery.
- Student awareness of skill required in violin playing through personal experimentation
- Alternation of practical "doing" with perceptual observation.
- Creation of mental models of the aspects required in violin playing.
- Reduction of cognitive uncertainty and stress associated with learning new content.

Conclusions

The exercises and the approach to them are designed to develop multiple aspects of the skill of violin playing: intonation, rhythm, awareness of feedforward and feedback processes, connecting auditory and motor imagery, in addition to attempting to encourage experimentation and creating personally-relevant imagery. This can also assist in teacher-student collaboration and add to the concept of fun that has been established in the literature as being important in the primary school pedagogical process.

This mental training system aims to minimise the use of verbal instructions and promote self-discovery and awareness. It is designed to encourage students to find personal connections to the music and techniques they are learning, whilst also reducing fear of making mistakes by encouraging the learning process through experimentation and independent problem-solving.

2.4. Student Violin Playing Skill Second Stage Repeat Evaluation and Analysis of the Results

To begin testing the hypothesis of this dissertation, exercise one devised in the last chapter was carried out. As the lessons only lasted twenty minutes, the other exercises were not carried out at this phase of the research. This exercise was designed to help student awareness of pitch and intonation, combined with an awareness of the movements required to attain the pitches (see chapter 2.3).

The results are compared to the previous measurements before mental training took place and are then shown as a percentage. In these measurements, a percentage decrease in the overall range indicates that the range of the cents has decreased, which shows an improvement in intonation. Additionally, for the measurements of pulse and tempo, a decrease in the range of tempos played indicates that the tempo was steadier. The reduction in the number of fermatas also indicates this. The interquartile range was also calculated, since this shows how the range of the notes that were not completely out of the middle ranges had changed.

Approach taken to the exercise and during the measurements. Based on the literature and the theory proposed in this dissertation that proposes that student specific concentration of intonation actually makes it harder for the students to adjust their intonation, due to student supposition of external pressures and the resultant stress-related activation of the sympathetic nervous system, resulting in tension in the muscles, the intonation aspect here was not emphasised by the teacher. Indeed, the mental training used before this second measurement was the first exercise in the mental training system (see chapter 2.3). Indeed, the teacher described how in this exercise, there is an opportunity to relax the hand and feel a sense of ease – and used indirect imagery to achieve this: that the left hand can feel like cooked macaroni, or that it can feel as soft as a sponge. The students were also encouraged to think of their own imagery. The teacher also pointed out finger placements – the fact that the knuckles need to be above the level of the strings of the violin; that the fingers needed to be rounded over the string (see criteria and indicators in chapter 1.5). Additionally, the students were reminded that the left hand thumb needed to be placed gently on the neck of the violin.

Questions and significance. It is also important to note that these measurements took place in the same lesson as the baseline measurements were made and represents the immediate changes after the first use of mental training. However, these measurements are considered significant in two ways. Firstly, it shows the direct result of the mental training and secondly, immediate testing after mental training may help to corroborate other studies in the literature, where it has been anecdotally noted that professional musicians have made immediate improvements with the components of mental training. So a main question here can be: are there any immediate improvements with mental training? And, is there any basis to the claims in previous literature?

Measurements of intonation. These measurements were analysed using the same software as the first measurements – *Melodyne 4*.

Student 1 – The results of the mental training exercise were calculated and then compared to the intonation results from the baseline measurements (see Table 29 and appendix 5 for raw data).

Table 29. **Student 1: Comparison of the second and first measurements of intonation and the percentage change**

Student 1	**Intonation: 1st measurement (before mental training)**	**Intonation: 2nd measurement (after mental training)**	**Percentage change**
Description	**Measurements in cents**	**Measurements in cents**	**%**
Minimum	−100	−16	−84%
Maximum	121	115	−4.96%
Overall range	221	131	−40.72%
Interquartile range	22.5	32.75	45.56%

A considerable improvement (–40.72%), a reduction in the overall range of intonation by 40.72%, can be identified. Pitches that were too low (minimum values) in the first performance were also corrected after the mental training (–84%). A small improvement was also seen in the notes that were too high (–4.96%). Though not specifically emphasised by the teacher, the student was thinking more about the intonation during their playing in this second measurement, perhaps even feeling that there should be more change than necessary, which may account for the increase in the interquartile range, which increased (45.56%). However, pitches that were completely wrong in the first performance were corrected in the performance that took place after the mental training, which is shown with the reduction of the overall range (–40.72%).

Student 2 – Here, a large improvement can be seen in all areas. The notes that were pitched too low in the first measurement saw an improvement of –49.41%, and those that were too high, an improvement of –79.68%. Again, many incorrect notes were corrected, which decreased the overall range of the intonation (–99.47%). There was also an improvement in the interquartile range of –12.43%. (see Table 30).

Table 30. **Student 2: Comparison of measurements of intonation after and before mental training and percentage change**

Student 2	Intonation: 1st measurement (before mental training)	Intonation: 2nd measurement (after mental training)	Percentage change
Description	**Measurements in cents**	**Measurements in cents**	**%**
Minimum	−85	−43	−49.41%
Maximum	187	38	−79.68%
Overall range	272	86	−99.47%
Interquartile range	61.25	38	−12.43%

This student specifically reported that she enjoyed the mental training and that she now understood better where to place her fingers.

Student 3 – This student showed large improvements in areas of the statistical analyses. Although the range of notes that were too low in pitch before mental training had increased – become somewhat lower (−42.67%), the notes that were pitched too high before mental training had improved by −83.55% as well as the overall range (−48.72%) (see Table 31). Though perhaps not consciously realised by the student, the lowering of pitch of many of the notes may be the reason also why the low-pitched notes were also lowered: the student may have heard that many notes needed to be lowered, and so over-applied the principle.

General observations. An audible change was especially noted in the one and a half bars of the etudes – both in intonation and in rhythm – which will be analysed later. After this, both rhythm and intonation deteriorated slightly, suggesting that this student benefits from smaller excerpts of music to work upon.

Table 31. **Student 3: Comparison of measurements of intonation after and before mental training and percentage change**

Student 3	**Intonation: 1st measurement (before mental training)**	**Intonation: 2nd measurement (after mental training)**	**Percentage change**
Description	**Measurements in cents**	**Measurements in cents**	**%**
Minimum	−43	−75	−42.67%
Maximum	152	25	−83.55%
Overall range	195	100	−48.72%
Interquartile range	41.5	44	6.02%

Student 4 – This student showed improvement in key areas of the analyses. The notes that were pitched too low before mental training showed an improvement – they became higher in pitch – after mental training (by –56.25%). A heightening of higher notes was also witnessed (23.73%), which indicates that the student was again over-compensating; that she realised after the mental training that many notes needed to be raised in pitch and thus over-applied this principle. The interquartile range, however, showed an improvement (–30%), which indicates that the notes that were not on the outside borders had indeed improved (see Table 32).

Table 32. **Student 4: Comparison of measurements of intonation after and before mental training and percentage change**

Student 4	**Intonation: 1st measurement (before mental training)**	**Intonation: 2nd measurement (after mental training)**	**Percentage change**
Description	**Measurements in cents**	**Measurements in cents**	**%**
Minimum	−16	−7	−56.25%
Maximum	59	73	23.73%
Overall range	75	80	6.67%
Interquartile range	40	28	−30.00%

Student 5 – This student showed a 100 percent improvement on the notes that were lower than zero after the mental training. However, over-compensation again occurred: the upper range of intonation extended from 4 to 264 cents, an increase of 6500%. Whilst this is perhaps not desirable, it shows that the pupil is experimenting with pitches and realised that the pitches needed to be raised. Since the overall range and the interquartile range reduced by –34.65 and –51.78 percent respectively (see Table 33).

Table 33. **Student 5: Comparison of measurements of intonation after and before mental training and percentage change**

Student 5	Intonation: 1st measurement (before mental training)	Intonation: 2nd measurement (after mental training)	Percentage change
Description	**Measurements in cents**	**Measurements in cents**	**%**
Minimum	–400	0	100%
Maximum	4	264	6500%
Overall range	404	264	–34.65%
Interquartile range	309	149	–51.78%

Student 6 – Despite this student having some difficulties focusing during the lesson at first, there were noticeable improvements after the mental training. For instance, the student starting to sing the first note just before playing it. This may signal that the student is beginning to pre-hear the notes before they are being played. This result is interesting, since the mental training did not require the student to sing. It may indeed show that the aim of the mental training routine was taking effect: the training of the inner hearing and feedforward systems.

Table 34. **Student 6: Comparison of measurements of intonation after and before mental training and percentage change**

Student 6	Intonation: 1st measurement (before mental training)	Intonation: 2nd measurement (after mental training)	Percentage change
Description	**Measurements in cents**	**Measurements in cents**	**%**
Minimum	–89	–93	4.49%
Maximum	204	134	–34.31%
Overall range	293	227	–22.53%
Interquartile range	43	49.75	15.70%

Improvement could be seen especially in the overall range by –22.53 (see Table 34) percent and the notes that were pitched too high had also been lowered by 34.31 percent. There was a marginal lowering of notes that were pitched too low (4.49%) and the interquartile range had risen a little (15.7%), which shows that there is still some improvement needed. However, by considering the statistical calculations together with the pedagogical observations, it seems that the improvement had started.

Student 7 – This student reportedly enjoyed the mental training routine and there was also an improvement of intonation. The overall range of the intonation was reduced by –29.13 percent and the lowest intonation was at just –13 cents – a –76.36 percent improvement from the first measurement, which is within the ideal range specified earlier in this dissertation (see Table 35). The notes that were pitched sharp did reach 60 cents – slighter higher than the first time, though again the student may have over-applied the concept that some notes needed to be higher. The reduction (–29.13 percent) of the overall range and the interquartile range (–45.16 percent) indicates a large improvement of intonation for this student in that category.

Table 35. **Student 7: Comparison of measurements of intonation after and before mental training and percentage change**

Student 7	Intonation: 1st measurement (before mental training)	Intonation: 2nd measurement (after mental training)	Percentage change
Description	**Measurements in cents**	**Measurements in cents**	**%**
Minimum	−55	−13	−76.36%
Maximum	48	60	25.00%
Overall range	103	73	−29.13%
Interquartile range	31	17	−45.16%

Student 8 – Observation of this student after the mental training showed an improvement in posture and more self-confidence in playing. The student did not look at the pedagogue for confirmation of the notes being played and used the correct fingerings independently. Hesitations and fermatas reduced. There was an improvement of intonation – this could be seen by a reduction in the interquartile range of –25.21 percent (see Table 36). Though it would have been nice to see a greater improvement in intonation, it is interesting that the student seemed to use the mental training routine to address issues of posture and correct hand positions and fingering – and that this was done independently.

Table 36. **Student 8: Comparison of measurements of intonation after and before mental training and percentage change**

Student 8	Intonation: 1st measurement (before mental training)	Intonation: 2nd measurement (after mental training)	Percentage change
Description	**Measurements in cents**	**Measurements in cents**	**%**
Minimum	−76	−90	18.42%
Maximum	69	71	2.90%
Overall range	145	161	11.03%
Interquartile range	59.5	44.5	−25.21%

Student 9 – This student's intonation improved after the mental training (see Table 37) and seemed to create a novel distraction away from other external worries that she had at that time. Whilst the excerpt worked upon was only two bars in length, the results of the measurements show a decrease in the overall range (–63.47 percent) and interquartile range (–68.26 percent). The tone and posture components only improved slightly.

Table 37. **Student 9: Comparison of measurements of intonation after and before mental training and percentage change**

Student 9	Intonation: 1st measurement (before mental training)	Intonation: 2nd measurement (after mental training)	Percentage change
Description	**Measurements in cents**	**Measurements in cents**	**%**
Minimum	–78	–36	–53.85%
Maximum	141	44	–68.79%
Overall range	219	80	–63.47%
Interquartile range	141	44.75	–68.26%

Overall results on intonation before and after mental training. When analysing the, it is possible to conclude that overall, mental training has a positive effect on the intonation of the violin students. As can be seen (see Fig. 48), the range of the intonation dropped in most cases (77.78 percent) after the mental training routine. There were only two instances when the mental training did not make a significant difference to intonation in the measurement of overall intonation range (students 4 and 8), but those students' interquartile ranges showed that their intonation had indeed improved – for student 4, a decrease of –30 percent (from 40 to 28 cents) and for student 8, a decrease of –25.21 percent (from 59.5 to 44.5 cents). Additionally, since these students already had a relatively small range of intonation, the interquartile range shows that the notes are within the range of ideal criteria identified from the recordings of professional violinists. Therefore, it is possible to ascertain that each student's intonation did improve after the mental training routine. It should also be noted that student 8 decided that the exercise gave an opportunity for sorting out issues of posture.

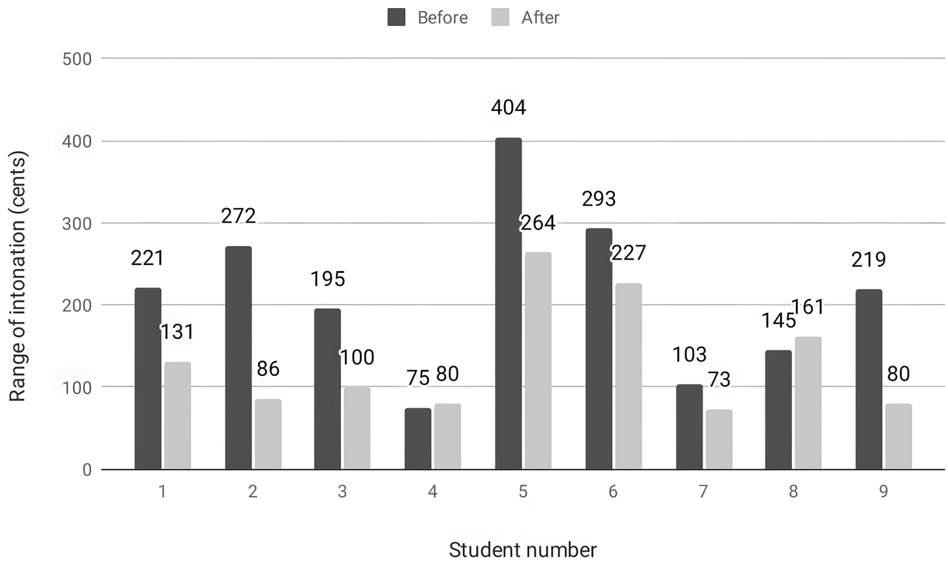


Figure 48. **Range of Intonation before and after mental training**

Using SPSS analysis of the data, a paired-samples t-test comparing the overall ranges of student intonation before and after the mental training routine was carried out. It showed a significant difference between the means before (M = 212.89, SD = 103.13) and after (M = 146.56, SD = 73.60) the mental training routine; $t(8) = 2.59$, $p = 0.032$.

The Kruskall-Wallis test was used to compare the individual distributions of students' intonations before and after a mental training routine. The results showed that the distributions of intonation were unique to each student in both the pre- and post-training periods ($p < 0.001$). This suggests that the mental training routine did not have a uniform effect on all of the students' intonation, but rather it helped to change the intonation ranges in an individualised.

A visual comparison of the intonation ranges before and after mental training (see Fig. 49) shows that the ranges are more tightly clustered and there are fewer instances, particularly in students 1, 5, and 7, of pitches below zero, suggesting an improvement towards the intonation used by professional violinists.

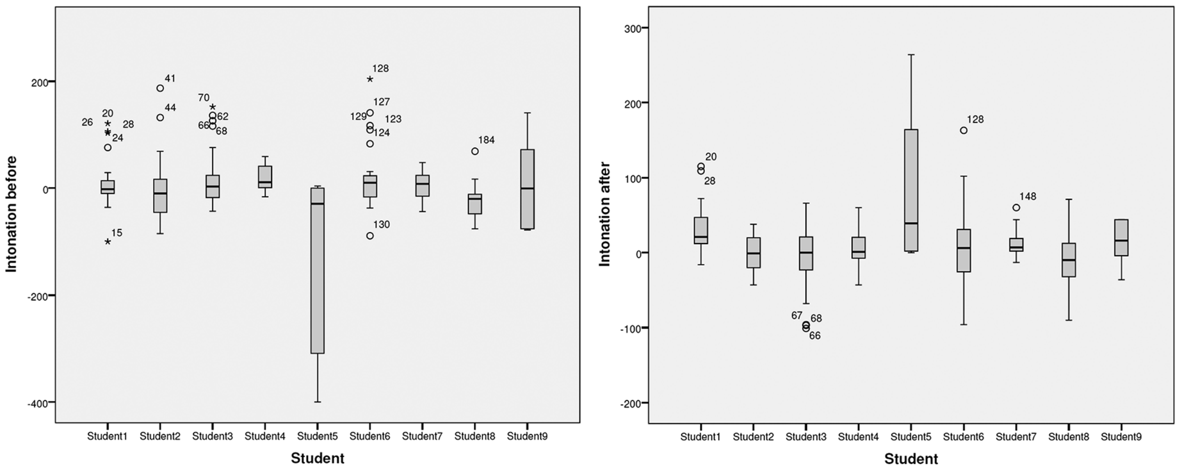


Figure 49. **Range of Intonation before and after mental training**

Changes in tempo, pulse and tone production. Whilst this first mental training session was devised to assist in illustrating the general musical concept of the musical excerpt, it became apparent from observations, that apart from the improvements in intonation, an effect was taking place also on pulse and tone production. Therefore, the recordings were analysed using the computer software *Melodyne 4* and then the data was statistically analysed in *Google Sheets* for an indication of changes in pulse and in Audacity to detect any changes in volume. The range of the tempos before and after were then entered into a graph (see Fig. 50), whereby it is possible to see that the range of pulse in most cases (77.78) had reduced, indicating that the pulse had become more steady.

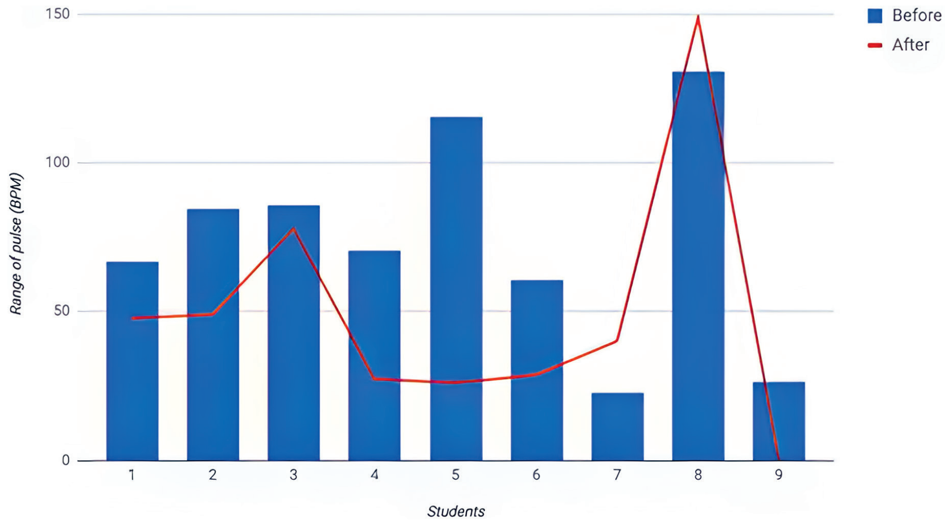


Figure 50. **Range of Pulse before and after mental training**

Additionally, the number of fermatas – inadvertent pauses in the music – had reduced significantly (see Fig. 51). For student 1, the fermatas had reduced from 4 to 1, a reduction of 75 percent. Student 2's fermatas had reduced 40 percent from 10 to 6 fermatas. Student 3's fermatas reduced from 6 to 3 a 50 percent reduction. Student 6's fermatas reduced 100 percent from 2 fermatas to none at all and student 8's fermatas reduced from 10 to 7 – a reduction of 30 percent.

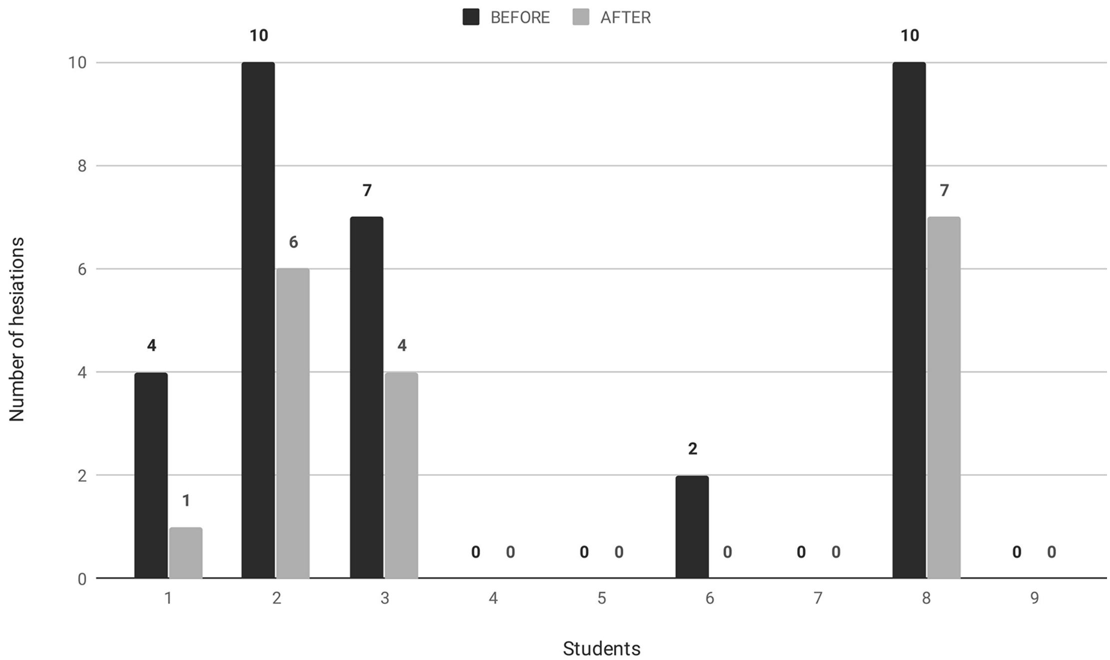


Figure 51. **Number of fermatas before and after mental training**

Since many of the fermatas originated from areas in the music before shifts and string crossings and before notes that with uncertain intonation, the reduction in the number of fermatas suggests that the students had a clearer understanding about intonation, finger placements, position changes, and concept of pulse after the mental training.

Further analysis was conducted using SPSS and the Wilcoxon Signed-Ranks Test. This is a non-parametric statistical test that is used to determine whether there is a significant difference between two related samples, such as a before and after measurement. The test is appropriate to use when the data being analysed is not normally distributed, as in the data collated from this research.

In this case, the test is being used to compare the overall pulse of all students before and after the mental training routine. The test found that there is a statistically significant difference between the pulses before and after the mental training ($Z = 3.162$, $p = 0.002$), with the pulses becoming more even after the mental training.

The Z-score of 3.162 indicates how far the observed difference is from the mean difference that would be expected if there were no real difference in the population. The lower the p-value (the probability of observing the test statistic if there is no real difference in the population) the more evidence you have that there is a real difference. In this case, $p = 0.002$, which is below the commonly used threshold of 0.05, indicating that the result is statistically significant, meaning that it is unlikely to be due to chance. So we can conclude that overall, the mental training routine led to a significant improvement in the evenness of students' pulses.

Pedagogue evaluation after mental training. The results of the pedagogue evaluation revealed an improvement after this first stage of mental training (exercise 1) – especially in the areas of intonation and rhythm, which tallied with the evaluations from the computer software. Students 4 and 7 showed a slight reduction in whole body posture (see Table 38). This may be due to the fact that this was not emphasised in the sessions, or perhaps due to the fact that these students were concentrating more on intonative and rhythmic components. It is interesting to note that these two students did improve nicely in those areas according to the previous tests.

Table 38. **Pedagogue evaluation card completed after mental training exercise 1**

	CRITERIA							
Student	Musical text	Rhythm	Posture			Tone quality	Dynamics	Characters, emotions, musical expression
	Intonation, fingering	Bow division	Left hand	Right hand	Whole body	Sound points	Dynamic contrast	Mixture
1	2	1	2	2	2	1	1	1
2	2	2	2	2	3	2	1	1
3	2	2	2	2	2	2	1	1
4	2	2	2	2	1	2	1	1
5	2	2	1	2	1	2	1	1
6	2	2	2	2	1	2	1	1
7	3	2	2	1	1	2	2	1
8	2	1	2	2	2	1	1	1
9	2	2	1	1	2	1	1	1

Comparison of pedagogue evaluations before mental training began in December 2015/ January 2016 and after the mental training exercise in January 2016 (see Table 39) confirms the results of the statistical analysis: that the exercise was most effective in improving intonation and rhythm. Dynamics, music characters and expression were not addressed in this particular stage of the mental training system. Accordingly, the pedagogue evaluation card reveals that these areas need to be worked upon in subsequent mental training sessions.

Table 39. **Pedagogue evaluation comparison before and after exercise 1**

	CRITERIA																	
Student	**Musical text**		**Rhythm**		**Posture**						**Tone quality**		**Dynamics**		**Characters emotions musical expression**		**Scores**	
	Before	**After**	**Before**	**After**	**Before**	**After**	**Before**	**After**	**Before**	**After**	**Before**	**After**	**Before**	**After**	**Before**	**After**	**Before**	**After**
	Intonation, fingering		**Bow division**		**L. hand**		**R. Hand**		**Whole body**		**Sound points**		**Dynamic Contrast**		**Mixture**		**Total**	
1	1	2	1	1	2	2	1	2	2	2	1	1	1	1	1	1	10	12
2	1	2	1	2	2	2	2	3	3	3	2	2	1	1	1	1	13	16
3	1	2	1	2	1	2	2	3	1	2	2	2	1	1	1	1	15	13
4	1	2	2	2	1	2	1	3	2	1	2	2	1	1	1	1	11	14
5	1	2	1	1	1	1	1	2	1	1	1	2	1	1	1	1	8	11
6	1	2	1	2	1	2	1	2	1	1	1	2	1	1	1	1	8	13
7	2	3	1	2	2	2	1	1	1	1	2	2	2	2	1	1	12	14
8	1	2	1	1	1	2	1	2	2	2	1	1	1	1	1	1	9	10
9	1	2	1	2	1	1	1	1	2	2	1	1	1	1	1	1	9	11

Expert string player evaluation of audio recordings made before and after the exercise, where both evaluations were performed in January 2016 reveal similar improvements (see Table 40 and 41).

Table 40. **Student Evaluation Card: Expert String Player 1 Before and After**

Student	CRITERIA											
	Musical text		Rhythm		Tone quality		Dynamics		Characters emotions musical expression		Scores	
	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After
	Intonation, fingering		Bow division		Sound points		Dynamic Contrast		Mixture		Total	
1	1	2	1	2	1	2	1	1	1	1	5	8
2	1	2	1	2	2	2	1	1	1	1	6	8
3	1	2	1	2	2	2	1	1	1	1	6	8
4	1	2	2	2	1	2	2	2	1	1	7	9
5	1	2	1	1	1	2	1	1	1	1	5	7
6	1	2	1	1	2	1	1	1	1	1	6	6
7	1	3	2	2	2	2	2	2	1	1	8	10
8	1	2	1	2	1	2	1	1	1	1	5	8
9	1	2	1	2	1	2	1	1	1	1	5	8

Table 41. **Student Evaluation Card: Expert String Player 2 Before and After**

Student	CRITERIA											
	Musical text		Rhythm		Tone quality		Dynamics		Characters emotions musical expression		Scores	
	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After
	Intonation, fingering		Bow division		Sound points		Dynamic Contrast		Mixture		Total	
1	1	2	1	2	1	2	1	1	1	1	5	8
2	1	2	1	2	2	2	1	1	1	1	6	8
3	1	2	2	1	1	2	1	1	1	1	6	7
4	1	2	1	2	1	2	1	1	1	1	5	8
5	1	1	1	1	1	2	1	1	1	1	5	5
6	1	1	2	2	2	2	1	1	1	1	7	7
7	1	2	2	3	2	3	2	1	1	1	8	10
8	1	2	1	2	1	2	1	1	1	1	5	8
9	1	2	1	2	1	2	1	1	1	1	5	8

Observations and discussion

Students reported that they enjoyed participating in the mental training routine and it was observable that the students enjoyed the change from the approaches carried out before. It became obvious during some of the sessions that the original idea of working on an eight-bar phrase seemed to be a little too long for the students to remain attentive. The excerpts were therefore reduced to within two to four bars, depending on the concentration span of each student as assessed by the pedagogue and expressed by the student. Additionally, the part of the mental training exercise where the students follow with the bow only could perhaps be omitted if the pedagogue feels that the exercise is becoming too long for that particular student. This may gain from being experimented with in future mental training tests.

After the mental training, it was interesting to see how each student concentrated upon what they chose to be more actual. For some, the emphasis seemed to be on rhythm, for some on intonation, whilst some students seemed to think they would concentrate on posture, when in actual fact it was clear that they were trying to improve their intonation. Whilst these occurrences may have happened in any method, what separates mental training from other approaches is that the students have not been issued with verbal instructions. They were not asked to listen to their intonation, or make sure that they are playing in time; they did so automatically after the mental training exercise.

Indeed, a significant observation of all of the students was that even if the fingers had been in slightly the wrong position in the silent miming phase of the mental training – the phase where the students fingered the musical excerpt and listened to the teacher playing – when they played the excerpt themselves, they quickly adjusted their finger positions to produce the correct sound. Thus, the students seemed to be able to compare what they had heard during the initial stages of the exercise, with what they actually played. This strongly suggests that they had formed a stronger auditory-motor link.

Another important observation was that the students became more motivated to experiment and reach the goal of the sound which had now become their mental model. It is possible to conclude from the computer analysis of the tests, that the students' goals must have been fairly strong – since in many of the tests, the students over-applied a principle: of raising or lowering the intonation of notes to more notes than necessary for instance. One student even remarked that something is not quite right with their playing and that and they would like to experiment some more, this differed from the violin playing in the first measurements, where some students were looking to the teacher for confirmation of their playing and where some did not notice any issues and problems with their own playing.

It is interesting to note, that whilst research in psychology and neuroscience has identified that the brain cannot efficiently multitask – that is, work efficiently on one task at a time, the concepts that the students gained in the mental training in most cases improved *both* intonation and rhythm. Perhaps this happened precisely because the tasks had not been verbalised. As E. Engestrom notes in relation to general pedagogy, actual problem-solving tasks – like those presented in the classroom situation provide false situations for students, since there is usually only one right answer that is externally driven from the teacher. This could be similar to the tradition in the violin learning process, where the pedagogue asks the student to concentrate on their intonation. This task then becomes something that the teacher has evidently noticed and there is therefore a correct, externally recognised, answer somewhere, but this answer, or correct intonation, is perhaps not clear to the student, which causes confusion and a mental state that makes it difficult to concentrate on or pay attention to on other tasks. However, when a task is not specifically given, but there is sufficient information and opportunity provided for the student to find and improve any existing issues that the student identifies herself, it may be possible that more can be worked on at once and a harmonic, more complete multi-modal mental model can be constructed. Hence, the observation by W. T. Gallwey, that a reduction of verbal instructions is successful in a learning situation. This concept may indeed require further research.

Interestingly, the improvements noted in this chapter happened after the first use of the mental training. This almost instant improvement is something noted in the literature on mental training with already-trained practitioners, but until now not noted in mental training with students.

The next chapter will analyse the effects of the continued use of mental training and how the mental training system can assist in the learning of the remaining aspects in the violin skill improvement model: namely that of musical expression and dynamic contrast.

Conclusions

- The students showed interest in the mental training session and reported that they enjoyed the change from previous methods used in lessons.
- Many students were able to identify, assess and correct their mistakes.
- The fingerings and positions used were correct after mental training.
- Students became more independent and ready to continue experimentation-playing on their own.
- Students did not have to be verbally prompted by the teacher to make adjustments to their playing.
- Students decided themselves which aspects needed to be improved after the mental training.
- The exercise already showed significant improvements in aspects of intonation, pulse/rhythm and posture.
- The immediate self-correction of incorrect notes during playing after the mental training suggests that the students were forming the auditory-motor link identified in the literature as a necessary skill for mastery of a musical instrument.

2.5. Third and Fourth stage Evaluations and Analysis of the Results

The encouraging results of the first mental training sessions led to further questions. Could the improvement be maintained over time? How do the other exercises in the system affect aspects relating to dynamic change and musical expression?

This chapter will attempt to ascertain some of the answers to these questions; to assess if further use, both in the classroom and independently of the mental training system, continued to assist with improvements.

In the beginning of this third stage students were again presented with mental training exercise number 1 one month after the first tests were made.

Observations and Results for exercise 1 (February 2016)

Student 1 – This time, the student chose to play a three-octave scale of A major. She was keen to improve the scale in the same manner that she had improved the etude. As noticed previously, this student had had problems remaining in a certain key – she often forgot the sound of the tonic of the key in which she was playing – indicated by the fact that the tonic note was played below or above the required pitch when repeated in the same scale. This happened again in the first play-through of the scale carried out for this experiment (see Table 42). But after the first exercise of mental training, the student was able to correct this and also play further in the scale without help from the teacher – that is, the student was also much more confident about position changes and fingering. Significantly, the overall range had reduced by −53.97%. The lowest pitches (ones that were below 0 in equal temperament) had risen and the notes that were too high had fallen, which is what would be expected, if the intonation was improving and becoming closer to a professional's intonation.

Table 42. **Intonation of student 1 before and after mental training**

Student 1	**Intonation: 1st measurement (before mental training)**	**Intonation: 2nd measurement (after mental training)**	**Percentage change**
Description	**Measurements in cents**	**Measurements in cents**	**%**
Minimum	−79	−28	−64.56%
Maximum	110	59	−46.36%
Overall range	189	87	−53.97%
Interquartile range	104	22	−78.85%

Compared with the first use of the mental training exercise with this student, she was able, overall, to correct the intonation more accurately – that is there is an even greater percentage improvement of intonation compared to the improvements noted in the first use of mental training (see chapter 2.4).

Student 2 – This student now chose to play an excerpt from an etude by F. Wohlfahrt. The student was much more confident than in the first round of mental training, which was reflected by their confident playing, signified by a more stable sound. Their bowing was more relaxed and stable, and the bow was played with more weight than before, which produced a more focused, solid sound. Student awareness of pitch was also more pronounced (see Table 43), and the fact that the student wished to play was signified by her wanting to play the excerpt several times independently before starting the lesson.

Table 43. **Intonation of student 2 before and after mental training**

Student 2	**Intonation: 1st measurement (before mental training)**	**Intonation: 2nd measurement (after mental training)**	**Percentage change**
Description	**Measurements in cents**	**Measurements in cents**	**%**
Minimum	−97	−31	68.04%
Maximum	79	80	1.27%
Overall range	176	111	36.93%
Interquartile range	11.5	13	13.04%

Student 3 – This student chose to work on an excerpt by the Latvian composer Raimonds Pauls: *Ilgais ceļš kāpās* ('Long Road in the Dunes'). Improvements were particularly noticeable in the overall range and interquartile range of intonation with represented a significant improvement in intonation (see Table 44).

Table 44. **Intonation of student 3 before and after mental training**

Student 3	**Intonation: 1st measurement (before mental training)**	**Intonation: 2nd measurement (after mental training)**	**Percentage change**
Description	**Measurements in cents**	**Measurements in cents**	**%**
Minimum	−58	−31	68.04%
Maximum	268	80	1.27%
Overall range	326	111	36.93%
Interquartile range	117	58	50.43%

Student 4 – This student played the beginning of P. I. Tchaikovsky's "Dance of the Sugar Plum Fairy." Despite this student's eagerness to play, there was little improvement between their intonation before and after mental training (see Table 45). Interestingly, this student reported throughout the course of this research that they had never experienced visual mental imagery, had not ever dreamt in pictures, and additionally found difficulties in pre-hearing.

Table 45. **Intonation of student 4 before and after mental training**

Student 4	**Intonation: 1st measurement (before mental training)**	**Intonation: 2nd measurement (after mental training)**	**Percentage change**
Description	**Measurements in cents**	**Measurements in cents**	**%**
Minimum	−109	−100	8.26%
Maximum	100	37	63%
Overall range	210	137	34.76%
Interquartile range	129	95	26.36 %

Student 5 – This student played a scale in D major, two octaves. This student continued to improve their intonation with continued use of the mental training exercise which is again represented by the reduction in overall range of intonation to 140 cents and interquartile range (47 cents) (see Table 46).

Table 46. **Intonation of student 5 before and after mental training**

Student 5	**Intonation: 1st measurement (before mental training)**	**Intonation: 2nd measurement (after mental training)**	**Percentage change**
Description	**Measurements in cents**	**Measurements in cents**	**%**
Minimum	−119	−49	58.82 %
Maximum	223	91	59.24%
Overall range	342	140	59.06%
Interquartile range	113	47	58.41%

Student 6 – This student also played a scale in D major, two octaves. The main challenge that this student had to overcome was a wandering attention. However, the student had a very vivid imagination and sense of mental imagery and intonation had significantly improved in overall range and interquartile range (see Table 47).

Table 47. **Intonation of student 6 before and after mental training**

Student 6	**Intonation: 1st measurement (before mental training)**	**Intonation: 2nd measurement (after mental training)**	**Percentage change**
Description	**Measurements in cents**	**Measurements in cents**	**%**
Minimum	**−64**	**−38**	**40.63 %**
Maximum	**274**	**145**	**54.38%**
Overall range	**338**	**163**	**51.77%**
Interquartile range	**161**	**60**	**62.73%**

Student 7 – This student also chose to play an etude by F. Wohlfahrt. Improvements in intonation were distinctly noticeable post the mental training (see Table 48) and the student's

interquartile range fell within the range of the intonation belonging to professional violinists noted in chapter 2.1.

Table 48. **Intonation of student 7 before and after mental training**

Student 7	Intonation: 1st measurement (before mental training)	Intonation: 2nd measurement (after mental training)	Percentage change
Description	**Measurements in cents**	**Measurements in cents**	**%**
Minimum	–41	–30	26,83 %
Maximum	47	28	40,43%
Overall range	88	58	34,09%
Interquartile range	50	21	58%

Student 8 – This student played an extract from E. Dārziņš *Melaholiskais valsis* (*Melancholic Waltz*). This student had many notes that were under zero in equal temperament, which is not typical of a professional violinist's intonation. After mental training, however, the overall range had decreased and significantly, the lower values had increased (see Table 49).

Table 49. **Intonation of student 8 before and after mental training**

Student 8	Intonation: 1st measurement (before mental training)	Intonation: 2nd measurement (after mental training)	Percentage change
Description	**Measurements in cents**	**Measurements in cents**	**%**
Minimum	–145	–66	54.48
Maximum	1	30	2900%
Overall range	146	96	34.25%
Interquartile range	49.5	30	40%

Student 9 – This student played an excerpt from the *Fināla dziesma* (*Final Song*) by I. Kalniņš. This student also displayed improvements to intonation post mental training, especially in the overall range of intonation (see Table 50).

Table 50. **Intonation of student 9 before and after mental training**

Student 9	Intonation: 1st measurement (before mental training)	Intonation: 2nd measurement (after mental training)	Percentage change
Description	**Measurements in cents**	**Measurements in cents**	**%**
Minimum	–45	–30	33.33%
Maximum	139	43	68.35%
Overall range	184	73	60.33
Interquartile range	12	24.5	104.17%

Summary of Second use of mental training exercise

Similar to the first use of mental training, improvements in intonation were noted after this second use of mental training, but now all 9 students saw a reduction in the range of their intonation post versus pre-mental training (see Fig. 52), perhaps indicating that students were now becoming more aware of being able to adjust their intonation.

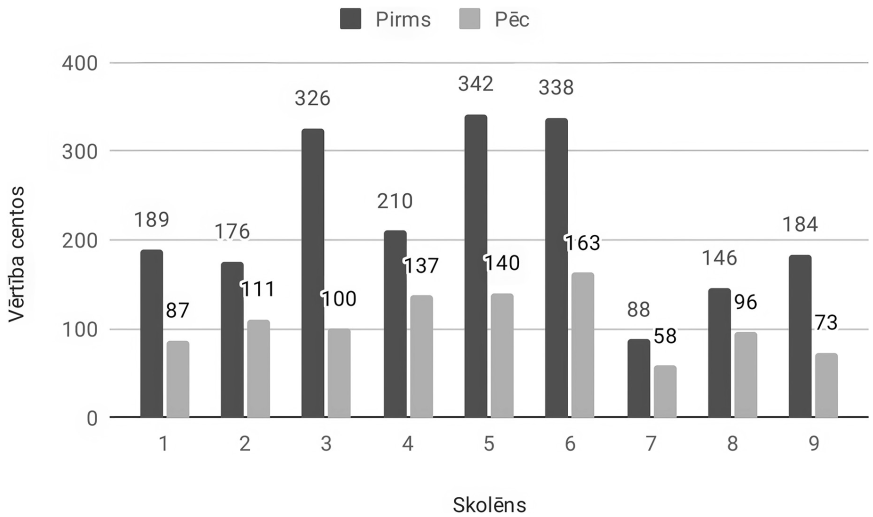


Figure 52. **Ranges of Intonation Before and After Second Mental Training**

Continued use of mental training and new tests, 2017 (Fourth Stage Observations and Evaluations). After the initial mental training exercise was carried out, the students continued its use throughout the remainder of the 2016 to 2017 academic year. In the next semester, in January to March 2017, new measurements were made involving the exercises in the devised mental training system (see chapter 2.3) designed for tone production and musical interpretation and dynamic contrasts (exercises 9, 11 and 5), and in September of the next academic year, (2017) for rhythm and intonation (exercises 3 and 4). Students 1 to 6 participated in this new academic year.

Exercise 11: "Elephant, Elephant." (January 2017)

A common technical issue witnessed in the baseline and repeat measurements of the pedagogue evaluations for all students was tone quality, and it was a criteria where no student received a high evaluation score. Since tone production is developed by gaining an awareness of bow speed and right arm weight, the exercise sought to develop self-awareness of these aspects.

Baseline Measurements

As a part of the exercise, but before imagery had been developed with the students, students were asked to play a long note throughout the entire bow on both up- and down-bows and to sustain it for as long as possible. The number of beats a student could play with a metronome beat of 80 BPM was notated (see Table 51).

Table 51. **The length of students' sostenuto on down and up bows at 80 BPM**

Student	Down Bow Count (80 BPM)	Up Bow Count (80 BPM)
1	12	13
2	9	9
3	11	14
4	8	7
5	4	4
6	8	7
7	3	7
8	40	46
9	10	9

A common issue noted during this task was that students were tensing their upper right arms, particularly when playing near the heel of the bow, resulting in students attempting to lift the entire right arm to produce a lighter sound at the heel, rather than allowing the elbow of the right arm to drop naturally. This would have enabled them to lighten the hand, producing a less "pressed" sound effortlessly.

Another observation during this task was that students were playing faster on down bows in the area of the bow from the heel to the middle and slower from the middle to the tip of the bow (see Table 52); that bow speeds were not even throughout the bow.

Table 52. **The length of students' sostenuto on down bows at 80 BPM from heel to middle and middle to tip**

Down Bows from Heel to Middle	Down Bows from Middle to Tip
5	10
4	5
6	14
5	7
3	7
4	8
2	6
10	25
3	9

Baseline observations also revealed that a thorough review of the basic bow hold was necessary. The students needed to focus on bending their thumbs and placing a "curved" little finger on top of the bow. Bending the thumb would facilitate a relaxed position for the hand while playing near the heel as well as during bow changes, enabling arm weight to enter the bow when playing at the tip.

Observations during and after the exercise

During this exercise, students were happy to "invent" three separate areas on the bow. The students also became interested in the silent electronic metronome that the teacher was holding, which the teacher then showed the student. This routine became most effective when taking a break between repertoire, or when it seemed like a student's concentration was wandering, and provided a method of focussing. The students were keen to find out how many elephants had been counted on each bow.

Whilst there were visible improvements in right hand posture and arm weight, comparing the number of beats that a note could be played *sostenuto* on one bow before and after the mental training routine confirmed that students were able to sustain a longer note post- versus pre- the mental training (see figure 53). Figure 5 presents a visual depiction of the percentage distribution of beats for the Down Bow technique. That is, it shows the percentages of the beats relative to the total number of beats for each student before and after mental training for each individual student. The bars on the graph represent the count or number of beats achieved for each student.

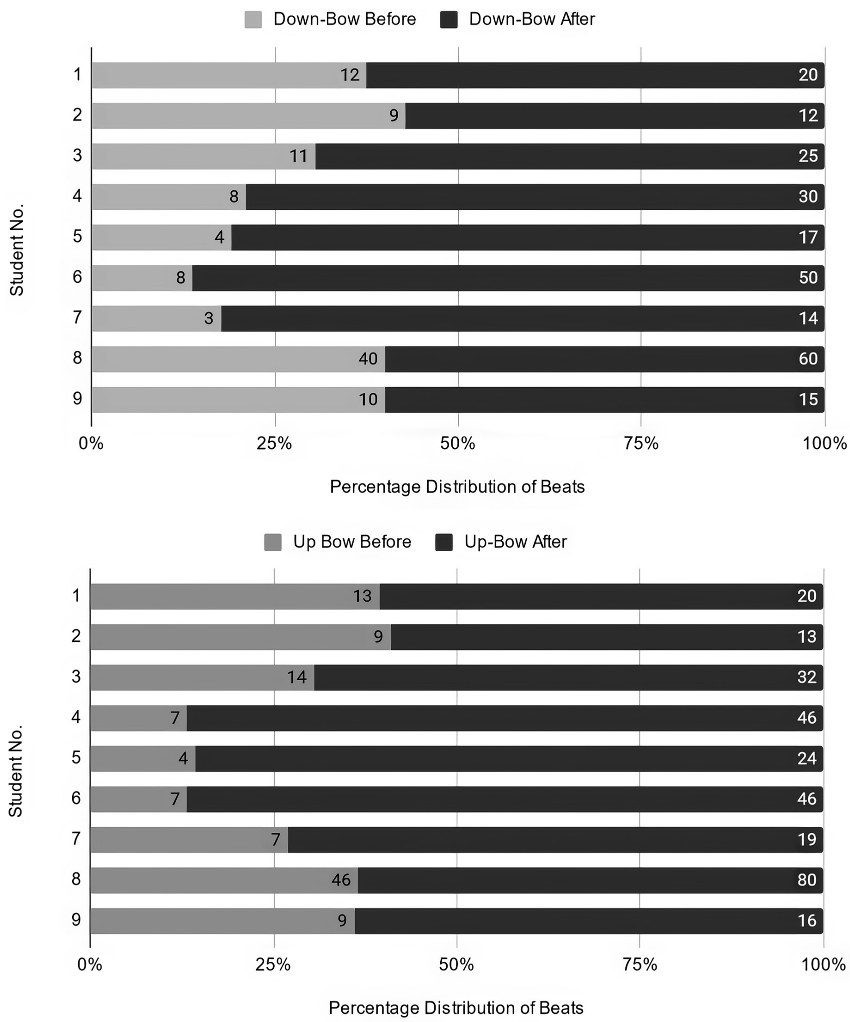


Figure 53. **Comparison of the number of beats at 80 BPM for down-bows and up-bows before and after mental training routine 11 "Elephant, Elephant"**

The most significant changes post routine were noted with students 3, 4, 5, 6, and 7, but all students had increased their bow control with improvements in both speed and weight. Significantly, students had managed to do this using imagery and were happy to experiment themselves and repeat the exercise, without needing lengthy technical explanations. Student 8, who had observed the routine with a different student whilst waiting for a lesson, sustained very long notes even on their first try, suggesting that observation alone had an effect. However, this student also managed to increase the length of their sostenuto notes during the routine. The students also enjoyed comparing the "number of elephants" counted before and after the exercise and started to become aware about where in the bow they were travelling faster or slower.

A Wilcoxon signed-rank test conducted on all the students' bow counts revealed a p-value of 0.008 ($Z = -2.666$) for down bows and a p-value of 0.008 ($Z = -2.670$) for up bows, showing statistically significant changes overall post the mental training routine (see Table 53).

Table 53. **Down and Up Bows before and after mental training routine no.1**

Student	Down Bow Count (80 BPM)		Up Bow Count (80 BPM)	
	Before	After	Before	After
1	12	20	13	20
2	9	12	9	13
3	11	25	14	32
4	8	30	7	46
5	4	17	4	24
6	8	50	7	46
7	3	14	7	19
8	40	60	46	80
9	10	15	9	16
Wilcoxon signed-rank test	$Z = -2.666$, $p = 0.008$		$Z = -2.670$, $p = 0.008$	

Other observations included the development of keywords for quick reference to different techniques. In subsequent lessons the terms "Cesis," "Sigulda," and "Riga" were adopted as keywords to denote the division of the bow into sections and describe specific areas of the bow to play, being utilised by both teacher and student. Students began to ask questions about where in the bow passages could be played and were able to experiment deliberately with playing in different parts of the bow. Students were also keen to repeat the mental training exercise in subsequent lessons, where further subdivisions of the bow were also discussed.

Exercise 9: "Emojis" (February 2017)

A common issue noted in the pedagogue evaluations before and after the first exercise was the lack of combined techniques conveying characters, emotion and musical expression. This exercise sought to do just that and do so in a way that would be personally-relevant to the student and encourage a purpose for repetitions and experimentation in practice sessions.

Baseline Measurements

To create a measurable element to this exercise, the number of times a student was happy to repeat their repertoire, or sections of it, was documented (see Table 54). Issues observed during these repetitions included a lack of attention and a tendency to become easily distracted, especially with student 4, who was distracted by an interest in the classroom piano, and student 5, who began talking about unrelated issues. These students evidently did not yet wholly grasp the purpose of repetition, finding difficulties identifying areas requiring improvement, even when the teacher provided explanations. A lack of attention to detail noted amongst all students suggested a need to refine concepts of an ideal sound, plus perhaps the need to lose any possible fear of making mistakes (see Table 54).

Table 54. **Number of repetitions of repertoire before mental training**

Student	1	2	3	4	5	6	7	8	9
No. of Repetitions	3	2	3	1	1	2	2	1	2

Observations During the and After the Exercise

This seemed to calm the students, reducing self-doubt that occasionally affected fluency during playing. Two students were unfamiliar with the term "emojis," prompting an explanation that they represented "faces" and "expressions." Some students asked whether they could also draw animals.The younger students were content with playing a single line of music and then asking the teacher to guess their characters. Some students asked why they needed the emojis; the teacher explained that they help to play the music in different ways or characters. The teacher then took the violin to demonstrate techniques and sound qualities that could portray a happy or sad mood, explaining that that was only one way to express those emotions; that they could experiment with their own sounds and emotions. Interestingly, all students were keen that the teacher should also draw emojis. No emphasis was placed on the concept of repetition or practice by the pedagogue, since it was hoped that this would be a positive consequence of the experimentation process.

The drawings created by the students in this routine were translated into keywords (e. g. happy, sad, dog, cat). The keywords were notated for each student and analysed together with the violin techniques employed (see appendix 7). Out of the 45 emojis drawn by the students, 31 were unique, indicating the individuality of ideas amongst the students. Only 8 emojis were repeated: Happy: 3 (occurrences), Sleepy: 3, Angry: 3, Dog: 2, Neutral: 2, Shock: 2, Scared: 2, Sad: 3.

Students used varying emotions in their imagery: student 2, for instance, created four images that represented opposite emotions and one neutral emotion: "happy" and "angry"; "sleepy" and "shock" and a "neutral" emoji with an expressionless mouth. These concepts inspired experimentation with contrasting dynamics and violin techniques. Interestingly, when categorising the emojis according to sentiment (positive, negative and neutral), all three categories were fairly evenly represented throughout the 9 students (see Fig. 54).

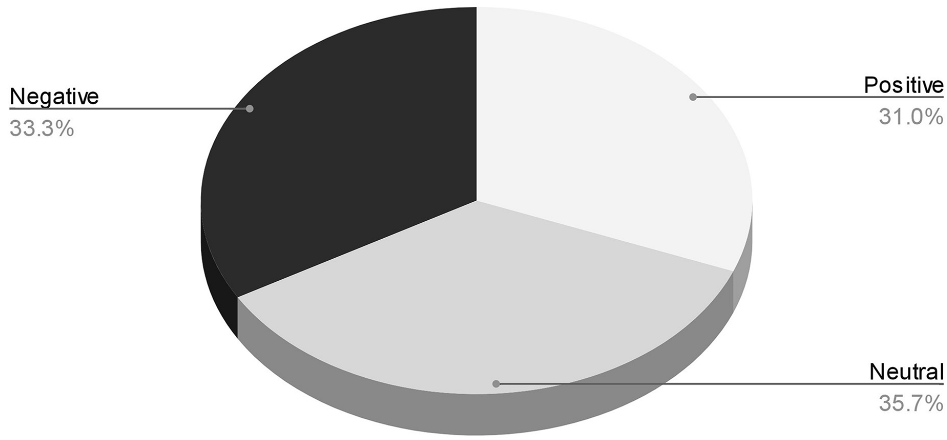


Figure 54. **Frequency of Positive, Neutral and Negative Sentiments**

A quasi co-occurrence matrix was used to detect the presence or absence of a sentiment for each student (see Table 55). "Yes" indicates the presence of a sentiment for a particular student, while empty cells indicate the absence of that sentiment.

Table 55. **Co-occurrence matrix for the sentiments associated with the drawings created by the student**

Student	Positive	Neutral	Negative
1	Yes		
2	Yes	Yes	Yes
3	Yes		Yes
4	Yes		Yes
5		Yes	Yes
6	Yes	Yes	
7		Yes	
8	Yes	Yes	
9	Yes		Yes

Based on the co-occurrence matrix, the following observations can be made, that:

- "Positive" sentiment is present in students 1, 2, 3, 4, 6, 8 and 9.
- "Neutral" sentiment is present in students 2, 5, 6, 7 and 8.
- "Negative" sentiment is present in students 2, 3, 4, 5, and 9.

Not all sentiments are present for every student; there were two students that had only one category of sentiment: happy (student 1) and neutral (student 7), there were no students that had only negative imagery. However, even the students that created imageries categorised as only having one sentiment (such as students 1, 5 and 7), the imagery was contrasting in different ways – such as the difference of sound created by a cat versus a dog (student 1) and light versus dark (student 5) and the concepts of sleeping versus fire (student 7).

Overall, this mental training routine encouraged experimentation with differing musical effects and violin techniques. The "discovery" of the differing sound points (points in the area between the bridge and fingerboard where the bow transverses the strings) provided a creative introduction to technique that is usually considered in the later stages of violin learning, plus experimentation with concepts, such as glissandi and tremolo, not found routinely in the repertoire at this stage. This experimentation assisted the students in becoming more comfortable with their instruments technically and musically. The routine also provided a purpose for repeating and practising their repertoire and/or work on sections. This occurred at least five times using the emojis created by the students (see Fig. 55).

Student	1	2	3	4	5	6	7	8	9
No. of Repetitions Before	3	2	3	1	1	2	2	1	2
No. of Repetitions After	7	5	6	5	5	6	5	5	6

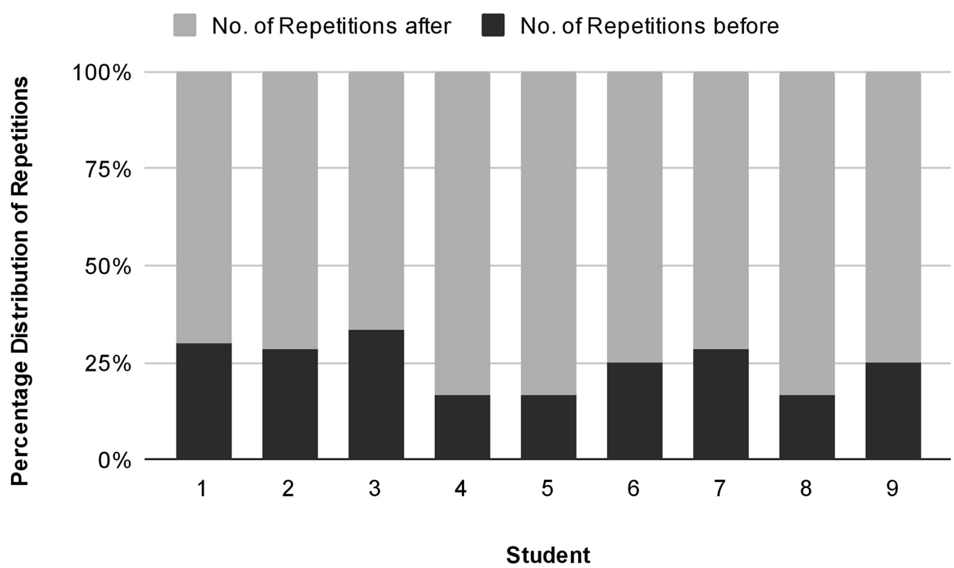


Figure 55. **Number of Repetitions Before and After Imagery Creation**

Interestingly, the students also invited the teacher to participate by asking them to draw and play in a similar process, after which some students asked to play their repertoire again, this time in the style of the teacher's emojis, and incorporated additional techniques they had observed in the teacher's performance. Eight out of nine students also wanted the teacher to play some repertoire with their emojis, so that they could also guess the emoji in which the teacher was playing.

The students took the emojis they created home and were told that they can continue to practise in this way and draw different emojis. All of the students brought the previously drawn emojis with them to their next lesson, and three of the youngest students had created artwork at home on larger pieces of paper (depicting a violin, a cat and a rabbit and a unicorn). This artwork was then incorporated into their lessons to inspire further musical interpretations.

Exercise 5: "Dynamics": Observations and results (March 2017)

Below are the results noted for the exercise to explore dynamic change.

Student 1 – In analysing the playing of the first student, it was possible to see that without the use of imagery the opposite of the desired outcome occurred: that the *piano* version was in fact louder than the *forte*. After creating a personally-relevant metaphor, the *piano* version indeed became quieter than the *forte*. The forte was imagined by the student as thunder in the countryside, whilst the piano was a quiet refrigerator.

It is important to note that the measurements in decibels appear in minus values. Anything zero or above would sound distorted, since zero represents the point at which distortion becomes perceptible with the electronic equipment used. Therefore, a value further from zero – for example, –20 is quieter than a value that is closer to zero – for example, –10. In this hypothetical example –20 is much quieter than –10.

In the case of student number 1, the phrase played *forte* before using mental imagery (–29.1 dB) was quieter than the *forte* achieved during mental imagery (27.4 dB). When the imagery was repeated (which was initiated by the student themselves) the *forte* phrase was even louder (–26.4 dB) (see Table 56). The use of mental imagery for a second time was not required in exercise No.5, but was recorded here to help illustrate the nature of both the measuring of dynamics in decibels (dB) and the development of the student, who was enthusiastic to repeat the mental imagery exercise without being prompted to do so by the teacher.

Table 56. **Dynamic contrasts with and without imagery of student 1**

	***Forte* (in dB)**	***Piano* (in dB)**	**Average difference between *forte* and *piano* (in dB)**
Without imagery	–29.1	–28.1	1.0*
1st time with imagery	–27.4	–29.6	2.2
2nd time with imagery	–26.4	–29.4	3

*values shaded grey represent a difference in dynamics in the wrong direction: that the piano is louder than the forte.

Student 2 – There was a small difference in dynamics between forte and piano before imagery was used (4.02 dB), which increased to 6.76 dB after employing mental imagery (see Table 57). The student decided that a loud school friend would serve as imagery for the *forte* and a much quieter school friend would serve as imagery for the *piano* section of the musical excerpt.

It is notable that not only did the imagery have an effect on her dynamic variation, but it also seemed to improve confidence in the musical text: pitches and rhythms were played much more confidently after imagery and the *forte* passage was played 1.78 dB louder after imagery than before. Additionally, during the first play-through (before mental imagery), the student played *piano* section much slower than the *forte.* After mental imagery, however, the piano section was played much more fluently and decisively (see Table 57).

Table 57. **Dynamic contrasts with and without imagery of student 2**

	Forte **(in dB)**	***Piano*** **(in dB)**	**Average difference between** ***forte*** **and** ***piano*** **(in dB)**
Without imagery	–24.52	–28.54	4.02
With imagery	–22.74	–29.5	6.76

Student 3 – This student's contrast between *forte* and *piano* increased during the use of mental imagery. The *forte* phrase became louder during mental imagery (–25.9 dB before, compared to –24.46 dB during), whilst the *piano* imagery facilitated quieter playing (–32.17 dB before, compared to –33.08 during). *Forte* imagery consisted of headphones being turned-up too loudly, and *piano* imagery consisted of calm wind blowing outside on a summer's day (see Table 58).

Table 58. **Dynamic contrasts with and without imagery of student 3**

	Forte **(in dB)**	***Piano*** **(in dB)**	**Average difference between** ***forte*** **and** ***piano*** **(in dB)**
Without imagery	–25.9	–32.17	6.27
With imagery	–24.46	–33.08	8.62

Student 4 – An improvement of dynamic contrast during mental imagery use was also noted with this student (see Table 55). Before imagery was used the *piano* phrase was actually louder than the *forte* phrase (highlighted in grey in Table 59)– the opposite of what was notated on the musical score. This student used the imagery of a loud television for *forte* and a quiet piano playing for the *piano* phrase, after which the *piano* phrase did indeed become quieter than the *forte.* It was also notable that this student's piano after imagery was 7.2 dB quieter than the piano before imagery (see Table 59).

Table 59. **Dynamic contrasts with and without imagery of student 4**

	Forte **(in dB)**	***Piano*** **(in dB)**	**Average difference between *forte* and *piano* (in dB)**
Without imagery	−28.8	−25.5	3.3
With imagery	−26.7	−32.7	5.9

Student 5 – During this student's first play-through without mental imagery, there was almost no difference, just 0.1dB, between the *forte* and *piano* playing, but during the use of personally relevant mental imagery, the difference increased to 4.9dB (see Table 60). The student used imagery of someone hammering on the wall for *forte* and a quiet mouse for the *piano* imagery.

Table 60. **Dynamic contrasts with and without imagery of student 5**

	Forte **(in dB)**	***Piano*** **(in dB)**	**Average difference between *forte* and *piano* (in dB)**
Without imagery	−26.1	−26.2	0.1
With imagery	−23.8	−28.7	4.9

Student 6 – Before imagery was used, there was only a slight, almost unnoticeable difference between this student's *forte* and *piano* phrases (0.27 dB). After the use of imagery, however, which consisted of a large barking dog for the *forte* phrase and a quiet bed for the *piano* phrase, the contrast was pronounced (10.78 dB) (see Table 61).

Table 61. **Dynamic contrasts with and without imagery of student 6**

	Forte **(in dB)**	***Piano*** **(in dB)**	**Average difference between *forte* and *piano* (in dB)**
Without imagery	−31.84	−32.11	0.27
With imagery	−27.99	−38.77	10.78

Student 7 – In this case, the *piano* version of the first play-through could not be analysed from the recording, due to a noise distraction in the classroom, but the results were still interesting, since they showed a difference in the playing of *forte* with and without mental imagery: that the forte was indeed louder with mental imagery than without it. Additionally, the difference between *forte* and *piano* was large in the mental imagery condition (see Table 62).

Table 62. **Dynamic contrasts with and without imagery of student 7**

	Forte **(in dB)**	***Piano*** **(in dB)**	**Average difference between *forte* and *piano* (in dB)**
Without imagery	–26.8		
With imagery	–24.7	–37.2	12.5
Difference between *forte* pre- and post-imagery	–2.1		

Student 8 – The difference in dynamics during the use of mental imagery was also noted with this student. *Forte* imagery consisted of headphones being accidently left on full volume when starting to watch something on YouTube and *piano* imagery consisted of "somebody whispering." Interestingly, the *piano* phrase remained very similar in volume both before and during mental imagery (–26.3 dB compared to –26.46 dB), but the *forte* was louder during mental imagery (–20.23 dB before, versus –26.46 during), hence the larger difference between *forte* and *piano* during mental imagery (3.75 dB before, compared to 6.23 after) (see Table 63).

Table 63. **Dynamic contrasts with and without imagery of student 8**

	Forte **(in dB)**	***Piano*** **(in dB)**	**Average difference between *forte* and *piano* (in dB)**
Without imagery	–22.55	–26.3	3.75
With imagery	–20.23	–26.46	6.23

Student 9 – Dynamic contrasts were noted before mental imagery use, however, the *piano* was louder than the *forte* (–27.08 for the *piano* and –30.61 for the *forte*) – the opposite of the requirement of the musical text. This changed, however, with the use of mental imagery: the *forte* was now louder than the *forte* without imagery (–24.50 with imagery, compared to –30.4 without imagery), and the piano was much quieter with imagery (–30.4 with imagery and –27.08 without). This student's imagery consisted of a loudly played violin for the *forte* and a quietly-played violin for the *piano*, and since the imagery was supposed to be of something personally significant, the nature of the imagery perhaps suggests that the violin was becoming more meaningful to the student and personally-relevant (see Table 64).

Table 64. **Dynamic contrasts with and without imagery of student 9**

	Forte **(in dB)**	***Piano*** **(in dB)**	**Average difference between *forte* and *piano* (in dB)**
Without imagery	–30.61	–27.08	–3.53
With imagery	–24.5	–30.4	5.9

Analysis of the Results of exercise 5

The process of the exercise revealed that students are able to create and employ imaginative imagery that is based on personally relevant experiences and that these helped to illustrate dynamics in music and also helped them connect to the subject content. The research suggests that mental imagery in the form of personally created metaphors was overwhelmingly successful; that dynamic contrast was indeed greater and more noticeable when using mental imagery. Observation of the process revealed that the use of metaphors created a light-hearted and positive atmosphere and also encouraged an element of fun. Interestingly, the violin playing techniques that the students used to create a *piano* sound included those that usually take many hours of technical explanations to achieve. For example, using the different sound points on the violin strings – moving the bow towards the fingerboard for quieter sounds and towards the bridge for louder sounds. Additionally, a variation of bow speed was observed between *forte* and *piano* sounds. These techniques, without the use of mental imagery, can take many words and demonstrations to perfect.

Additional observations to be noted were the effects on future student attitudes towards playing in the lessons following the mental imagery. In one case a lesson was scheduled very early in the morning and the pupil did not want to stand up to play. However, on remembering the use of the metaphors in the previous lesson, the student immediately stood up and with a good posture began to play the music on the violin with enthusiasm.

The collated results of the exercise show that the contrasts between *forte* and *piano* had increased in all students (see Fig. 56)

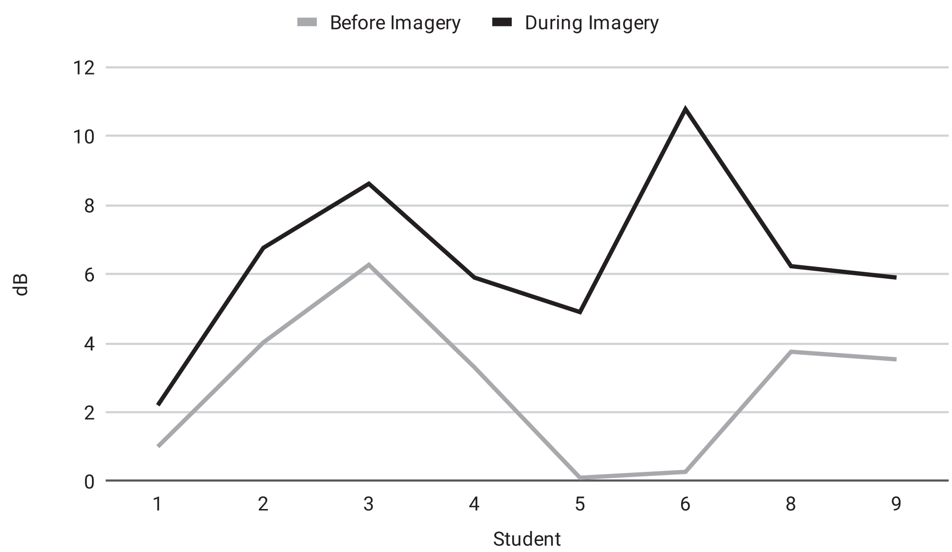


Figure 56. **Forte and piano contrasts before and during mental imagery**

Excluding student 7, because of incomplete data, a paired two-sample t-test was conducted on all of the student's results to compare the before and during mental imagery scores: in this case the difference between *forte* and *piano* volumes in (dB). The results indicate a significant difference between the means of the two sets of observations ($t(6) = -3.7505$, $p = 0.0095$). These results also confirm that overall, the metaphoric mental imagery has had a significant effect on the students' dynamic ranges.

Discussion of exercise 5

These results help to highlight the fact that mental imagery can help to introduce students to the concepts of musical interpretation creatively and collaboratively much earlier in the learning process. Because of the element of fun, it is possible that any nervousness or uncertainty about playing the violin is alleviated, so that learning can be achieved more effectively and enthusiastically. Interestingly, when the students were asked if they were aware exactly which techniques of violin playing, they were employing when they created dynamic contrasts, for example, most of them initially said that they were not. However, they were then able to then self-analyse and reflect on what they had done technically, indicating that they were beginning to develop independent awareness of technical skill.

In connection with the personally created mental imagery used in the mental training exercises, it was interesting to observe that the students started to use the imagery they created in the violin class in everyday circumstances. One student who used the imagery of a "tasty, cooked potato" in the right hand to help remember to keep the right hand in a rounded shape whilst holding the violin bow, once remarked in a different school location how she would now love to eat up that potato that she holds every lesson! This may show that this imagery building creates a light-hearted atmosphere as highlighted in the literature on mental training with children and suggests that creating the imagery increases collaboration between the teacher and student.

Another interesting observation that resulted from the process of mental training was its use for its assistance with student attention and concentration. One particular student (student 6) had issues of concentration. Considering that it was obvious that she was not really whole-heartedly involved in the lesson but trying to deal with issues that had occurred at home, which seemed to be occupying the student's mental imagery – it was decided that pictures of violinists past and present should be displayed in the classroom. The student immediately had questions about those pictures and started comparing the posture of old and modern violinists. This provided the focus on the violin lesson and additionally, the student became more aware of her own posture. Problems with concentration in the violin lesson also did not continue and by the end of the research period of this dissertation, the student had gained a good posture.

Observations and results for exercise 3: "My note, your note:" (September 2017)

Students 1 to 6 (six students) participated in this exercise. A common issue encountered by students in the "My Note Your Note" routine at the beginning, even when a tempo had been agreed upon between student and teacher, was hesitation when playing their musical texts. That is, the teacher needed to imagine an achievable tempo and establish this tempo throughout the routine in the following manner: once a student successfully played their note confidently, the teacher continued to play the next note in the tempo agreed at the beginning of the routine and maintaining the same pulse established at the start of the routine. This approach is supported by research, which indicates that understanding and prediction of pulse can be refined and adjusted in real-time during the process of pulse perception. This method proved to be effective, as students began to play their notes more accurately, in line with the tempo established by the teacher's playing and the initial tempo of the routine.

The results of a Wilcoxon Signed-Ranks Test showed that four out of five students had statistically significant improvements in their tempo when performing a certain task, after undergoing the mental training routine (see Table 65). This suggests that the mental training routine was effective in helping the students develop a sense of rhythm and pulse. However, one student, designated as student 4, did not show a statistically significant change in rhythm as measured by the test ($Z = -.604$, $p = .546$). Interestingly, this student did show a statistically significant improvement in intonation ($Z = -3.502$, $p < 0.01$). This suggests that this mental training routine may be more effective at bringing concepts of intonation into awareness for some students, rather than rhythm.

Table 65. **Wilcoxon Signed Ranks Test before and after mental training exercise No. 3 'My Note Your Note'. Test Statistics**[a]

STUDENT		**Intonation after – Intonation before**	**Tempo after – Tempo before**
Student 1	*Z*	$-.991^{b}$	-2.484^{c}
	Asymp. Sig. (2-tailed)	.322	.013
Student 2	*Z*	-1.888^{c}	-2.482^{c}
	Asymp. Sig. (2-tailed)	.059	.013
Student 3	*Z*	-1.733^{c}	−2.657b
	Asymp. Sig. (2-tailed)	.083	.008
Student 4	*Z*	-3.502^{c}	$-.604^{c}$
	Asymp. Sig. (2-tailed)	.000	.546
Student 5	*Z*	-1.925^{b}	-2.971^{b}
	Asymp. Sig. (2-tailed)	.054	.003
Student 6	*Z*	$-.991^{c}$	-4.166^{b}
	Asymp. Sig. (2-tailed)	.322	.000

a. Wilcoxon Signed Ranks Test

b. Based on positive ranks

c. Based on negative ranks

Observations and results for exercise 4 "air violin:" (September 2017)

In this exercise, it was observed that the students demonstrated an improvement in their intonation, specifically on the notes that they had previously played inaccurately during the initial play-through (which was stage 1 of the mental training routine). This improvement was reflected in the decrease of the range of intonation pre- and post-mental training routine in four out of the five students, as evidenced by the data in figure 57 (see Fig. 57).

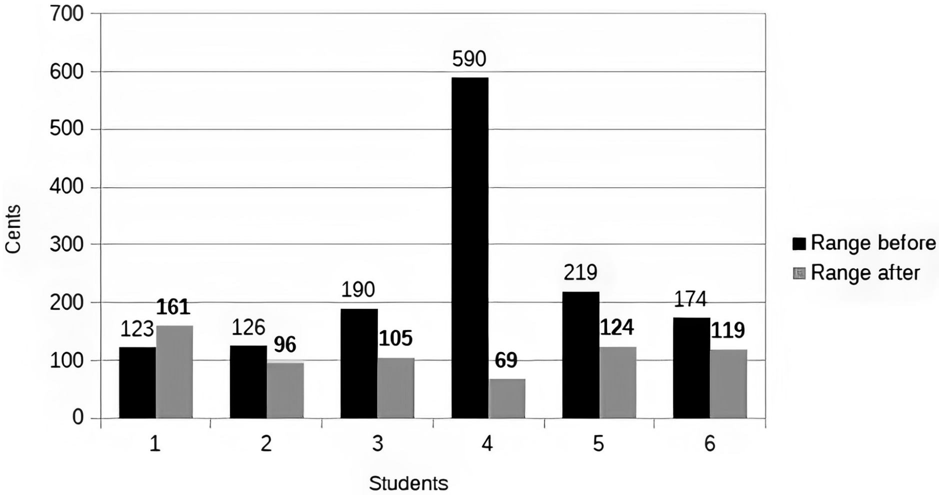


Figure 57. **Ranges of intonation (in cents) pre- and post- mental training**

The following Table displays the repeated pedagogue observation of student interest, physical, psychological and self-actualisation (see Table 66).

Table 66. **Student Interest, Physical, Psychological and Self-Actualisation Observation Table**

Student No.	Willingness to create personally-relevant mental Imagery	Independent use of mental training aspects	Punctual attendance of lessons	Willingness to arrange extra lessons	Willingness to participate in group activities	Eagerness to perform in front of others	Positive attitude towards challenges	Regular Practice Habits	Overall Enthusiasm (Total)
1	3	2	3	2	2	1	3	2	18
2	3	3	3	3	3	2	3	3	23
3	3	2	3	3	3	3	3	3	23
4	2	1	3	3	3	2	2	3	19
5	3	2	3	3	3	3	3	2	22
6	3	2	3	2	3	3	3	2	21
7	3	3	3	3	3	3	3	3	24
8	2	3	3	3	3	3	3	2	22
9	2	1	2	2	2	2	2	2	15

Based on the repeated observations after the implementation of mental training, the students' levels of enthusiasm and engagement in learning the violin have shown positive developments.

The consistently high scores across various criteria, such as willingness to create personal imagery, independent use of mental training, punctual attendance, active participation in group activities, and positive attitude towards challenges, reflect the students' increasing levels of self-motivation, self-expression, and the development of essential skills necessary for their holistic development as violinists. These positive outcomes suggest a positive trajectory towards self-actualisation and a strong foundation for their continued studies. It was encouraging to witness students using aspects of the mental training exercises whilst waiting for their lessons. Student number 7 began to use aspects of the "ghosting" exercise (see exercise 1) whilst holding the violin and aspects of the finger and thumb exercise whilst studying the musical notation. These "behaviours" mirrored the attributes of professional musicians witnessed in my own professional experience. This student's eagerness to perform also suggests that mental strategies were being developed and that these strategies were assisting the student to overcome any uncertainties that could contribute to performance nerves.

Observations of the remaining and combined use of the mental training exercises

Whilst it was possible to document the results of some of the exercises individually, the exercises were also used in combination and sequentially, depending on the individual requirements and interests of the student. The following is a description of the general observations of this combined use.

Exercise 8: *Concert process* combined with exercise 9 (*emojis*). These exercises were particularly popular with the younger students. The rehearsal of the concert process assisted in gaining both attention to the subject content or musical work, and served to develop concepts of self-awareness of skill, assisting the student to imagine the concert process and a feeling of seeing oneself from the side (quasi external mental imagery). Exercise 9 (*emojis*) especially assisted in encouraging the younger students to repeat their repertoire with a purpose. Additionally, playing in the character of the drawn emojis encouraged the students to explore playing techniques and experiment to gain the expressions and sounds they wanted to convey. They seemed to create a foundation for discussion and realisation of musical interpretation. Students requested to combine these two exercises independently, without prompting from the teacher.

Exercise 12: *melodic composition* combined with exercise 3 (*air violin*). All students without exception asked to repeat this routine. Younger students showed less inhibition in singing the individual pitches during notation, but most started singing or humming when repeating this routine. Some students had difficulty notating notes on the stave at first, which could explain hesitations when playing other repertoire (as noted previous exercises), since score-reading needed to be developed. Before playing their "compositions" on the violin, students were encouraged to sing and move their fingers as if playing, without the violin – a combination of mental training exercise 3 (*air violin*) and 12 (*composition*) though one student requested to play pizzicato on the instrument, instead of miming.

Exercise 10: *Bouncing ball*. Initially, the younger students found it difficult to bounce and catch balls whilst holding their violins and wanted to try also without the violin. Postures improved and left-hand pizzicatos helped develop rounded left-hand fingers. Some students asked for instructions upon which string to play, even when it was their turn to choose. One student forgot to plan or ask the teacher about which string to play pizzicato after bouncing the ball. This routine seemed to help one student to feel more light-hearted, who at the beginning of the lesson was feeling tired and upset after a different lesson at school. Indeed, using this routine at the beginning of lessons improved attention to violin playing and learning, especially with younger students.

Exercise 13: *Imitation and Improvisation*. All students chose to start by being the "parrot", rather than the "monkey", even when they were not yet aware of which character imitates or improvises. As a "monkey," the pedagogue introduced technical elements including *glissandi*, *tremolo*, *sul ponticello*, and left-hand pizzicato. Students were eager to try and replicate the sounds themselves. All students were also eager to change roles.

This routine also improved students' concentration, and they became more critical of their intonation throughout the remainder of the lesson, suggesting development of feedforward/feedback processes. Interestingly, this routine seemed to be more successful if introduced at the beginning of lessons as a quasi-warm-up, since students were then also more aware of demonstrations later in the lesson and imitated the teacher's playing more accurately. There was less student enthusiasm if the routine was introduced later in the lessons and imitations were also less accurate.

During the course of the research, it became apparent that the choice of mental training routine – exactly which one to use, the length of the musical text to be worked upon and where and when to place the mental training routine within the lesson – needed to be determined according to the student's individual needs, circumstances and environment. Pedagogues need to be dynamic, ready to adapt and improvise with the routines in creative collaboration with the student. Whilst this student-teacher dynamic is the largest change from the mental training utilised by professional musicians, it was encouraging to witness students beginning to use aspects of the mental training routines independently whilst waiting for their lessons and that these aspects were similar to the mental training techniques used by more experienced musicians.

After continued use of the mental training system, it is possible to conclude that:

- Repeated use of mental training has an increased positive effect on basic violin playing skill.
- The mental training exercises assisted in the realisation of the violin skill improvement model.
- Through student independent, unprompted use of aspects from the mental training routines, it is possible to conclude that there was increasing awareness of feedforward and feedback processes.

- The mental training exercises increased enthusiasm in violin playing and performance.
- Deliberate mental imagery as developed in the mental training exercises can significantly assist in the experimentation process of identifying techniques required for creating dynamic contrast, musical interpretation.
- Pedagogues need to be ready to be flexible, to adapt, combine and adjust the mental training exercises according to the student's needs, developmental stage, and classroom environment.

2.6. Expert Violin Teacher Interviews and Results

To ensure the integrity of the research, its theoretical foundation, the actuality and usefulness of the exercises developed in the empirical part of this study in pedagogical practice, expert string player pedagogues were interviewed. Eight separate interviews were carried out in total, with 8 pedagogues participating online from Latvia, England and the USA.

All ethical standards were upheld, ethics committee approval was obtained (71-46/112) and an informed consent form was signed by the participants. Participation in the interviews was voluntary and participants were informed that they may withdraw from the interview at any time. The interview consisted of only 8 questions (see appendix 9) to avoid participant fatigue. The participants were sent information about the doctoral research and the 15 exercises that formed the mental training system (see appendix 8) as an attachment to email a few days before the interviews took place. The duration of each interview: between 25 and 45 minutes.

The interviews included teachers who had knowledge and working experience in the Colour Strings and Suzuki methods in the UK and USA, as well as teachers from the Latvian music school system and all had been working as teachers for at least 10 years. In analysing the results of the first question of the interview, it was determined that the participants had an average of 25.5 years of professional experience (range: 10–50 years).

Analysing the results of the second question revealed the participants are generally aware of the cognitive processes connected to learning to play the violin.

Interestingly, the cognitive processes that the participants described are essentially those that have also been identified as part of the feedforward and feedback processes involved in playing a musical instrument in the scientific literature (see appendix 10). Thematic analysis of the results of the interview revealed three overarching themes for this question: 1) Cycle of mental/physical process of playing an instrument (connected to feedforward and feedback processes), represented by 4 participants; 2) Performance skill/practice (practising performing, optimum practice memorisation techniques), represented by 2 participants; 3) Individual/developmental aspects, represented by 2 participants (see Fig. 58).

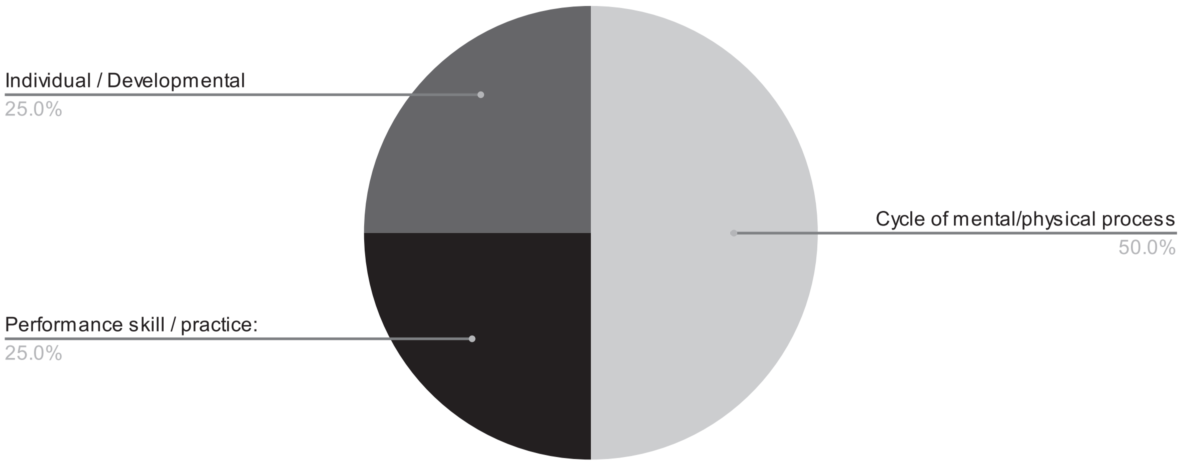


Figure 58. **Overarching themes for question 2**

Results of question number 3 revealed that there was only one participant that had a high familiarity with mental training; that it shared similarities to aspects of mental training, and one participant that had an awareness of it. There were no participants who said they had never heard of any aspects connected to mental training. All participants expressed that they incorporate some aspects of it in lessons (see appendix 11).

Question number 4 revealed that teachers use aspects that can be considered to be similar to mental training in their lessons. One participant mentioned however, that although they have an awareness of mental training, there is a gap between understanding it and applying it in pedagogical situations. The overarching themes of the techniques employed by five of the participants, however included: 1) Mindful Teaching and Learning, with sub-themes of: a) frequent revisiting and performance peaks, b) communication and expression, c) use of metaphors, visualisation, and Imagery. The second overarching theme was represented by four of the participants: Creative Teaching Approaches: sub-themes: a) physical exercises and perspective, b) questioning and exploration, c) fingered open string exercises and coordination, d) listening to recordings and tapping in pulse.

Question 5 revealed the participants' beliefs concerning commonly encountered problems in the learning of violin technique. Participants noted the individual technical and musical aspects of problems frequently encountered, but it was also possible to see how they thought that the aspects are connected (see appendix 13). For instance, the connection of intonation and tension in the left hand and/or note reading/fingering; bowing/bow holds and rhythm. Interestingly, tone production was only discussed by foreign participants. Eight overarching themes could be identified. This high number of themes indicates that there were numerous issues that occur in these beginning stages of learning the violin: 1) Integration of Technique and Musicality, 2) Challenges of coordination, 3) Challenges of Rhythm, 4) Challenges of Intonation, 5) Posture and Tension, 6) Note Reading, 7) Tone Production, 8) Individual Student Challenges (see Fig. 59).

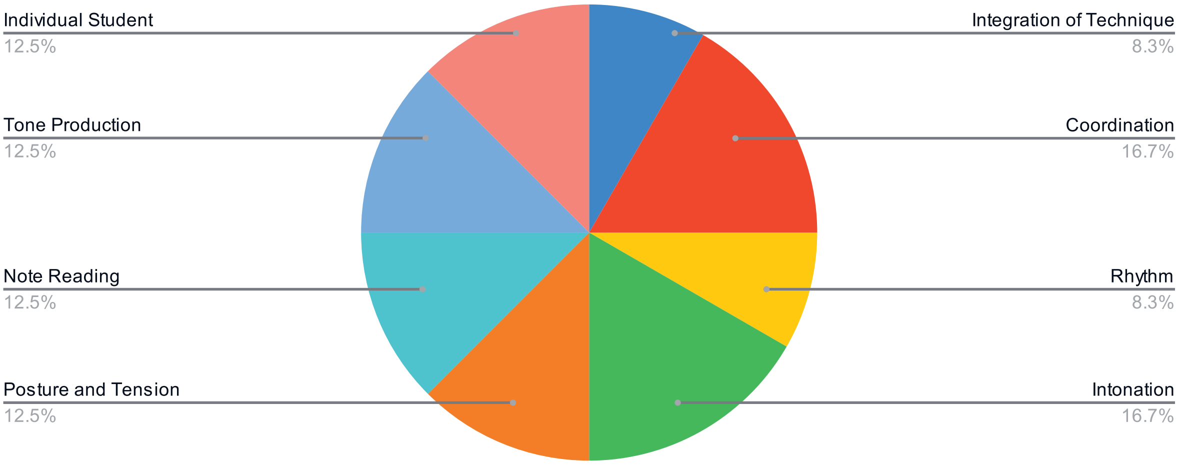


Figure 59. **Overarching themes for question 2: common difficulties of techniques for young violinists**

Analysis of the results of question number 6 revealed overwhelming positive regard for mental training (see appendix 14). All participants expressed that systematic approaches for pedagogical processes could address technical challenges; that mental practice, imagery and visualisation techniques are valid aspects of this process with mental training. Four of the participants expressed that mental training could assist in enhancement of movement and coordination and that the singing and listening exercises, together with the "finger and thumb" exercise could be a valuable addition to the pedagogical process.

Question 7 aimed to determine the teachers' opinions on the design of the mental training exercises devised in this study, and whether there are any aspects that would be useful in their own pedagogical practice. Five overarching themes were identified:

1) Positive Perception of Mental Training Exercises (all 8 participants): that they were universally usable (all 8 participants), that they were scientifically-based (2 participants), that they appreciated the visual and creative aspects of the exercises.
2) Desire for Further Development and Implementation: desire for expansion into different age groups and incorporation in pedagogy (1 participant), with 7 of the participants expressing that they could identify practical application in lessons.
3) Intent and Meaning in Music: 2 participants expressed that mindful and intentful playing could be developed and 1 participant expressed that the exercises could help to explore the violin as an instrument and music.
4) Creativity and Exploration in Teaching (2 participants): that the exercises could encourage experimentation and exploration
5) Usefulness in Various Teaching and Performance Aspects: Development of Memory, Exam Preparation, and that the exercises could be incorporated into regular lessons (4 participants).

Question 8 aimed to ascertain whether the participants believed that the mental training exercises could be integrated into the regular violin teaching and learning process and whether they could make any suggestions for their incorporation. Participants expressed that mental training could create engagement in lessons, develop mindfulness and exploration (see appendix 16). One participant reiterated a desire for their adaptation for different ages. Another believed that improvisation and character visualisation would help students, similar to that used in this study, whilst one participant expressed that mental training could assist with devising an individualised approach. Creativity and interactive learning were emphasised by another participant and that this could be encouraged using mental training; that the whole lesson could be devised around mental training; also, that the exercises could be chosen according to the needs and interests of the individual student.

Despite the differing nationalities and educational backgrounds of the participants, the expert teachers expressed common issues when assisting children to learn violin playing in this age group: coordination, posture and bow hold. Intonation and rhythm also appeared as common topics, as did practice methods and approaches. All teachers agreed that identifying methods of practising without "pushing" or "drilling" was desirable, and they were always looking for new ways of introducing concepts of practice.

Teachers with experience in Latvia also noted memorisation as a skill required to be developed in this age group and some expressed that they would like to see more exercises specifically for that.

One participant from the USA suggested that the exercises could be expanded into different age groups with systematic recommendations of how each exercise could be altered for both younger students at the ages of 5, 8, 11 and older students from about the age of 15.

Interestingly, mental training was a familiar concept to experts from the USA, where mental skills classes for conservatoire students are now included. However, one participant reported that the classes are not geared towards music pedagogy and the skills that are taught are taken directly from sports and noted that there is a gap between the research presented at conservatoire and practical application by violinists.

In analysing the results of the interviews, it can be concluded that:

- The experts believed that the mental training exercises developed in this thesis would help to address issues encountered when assisting children in this age group to learn the violin.
- There is a gap between current knowledge of mental training and its application in pedagogical processes.
- Aspects of mental training are used in lessons intuitively, without labelling it "mental training".
- Metaphors and similes were the most frequently used aspects of mental training with students in the primary school age group with expert violin teachers.
- Aspects of mental training are frequently used by teachers to separate and train left and right hand movements separately.
- All interviewees expressed an interest in experimenting with the mental training exercises that were designed for this study and believed that they could be utilised purposefully and effectively in the teaching and learning process of young violinists.

CONCLUSIONS

In order to achieve the goal set out in the theoretical part of this dissertation literature in pedagogy, neuroscience, psychology and violin playing was analysed on the mental and practical processes connected to learning and thought formation and the environmental and cognitive conditions that influence these processes. Literature was also analysed concerning the use of mental training and mental imagery in sport and music and then parallels were drawn between the processes described in this literature and the processes of learning identified in some of the latest literature in neuroscience and some more established theories in pedagogy. Historical use of mental training by violinists was also identified. Its use was traced to some of the violinists that assisted in creating the rich musical and cultural heritage of the violin, its music and its playing traditions. The theoretical chapters also identified problems in current practices of the pedagogical process of violin playing and learning in general and how, left unsolved, they can be the cause further problems: apathy towards learning, stress and dependence on medications to cope with the demands of a professional career as a professional musician and failure to self-actualise.

The synthesis and analysis of this combined, multi-disciplinary literature supported the idea of the introduction of mental training into pedagogical processes to assist in creating a personally relevant learning environment and provided a theoretical background to the concept of applying mental training in the violin teaching and learning process. It can therefore be stated that:

- There are proven links between thought, imagery, observation and action. An awareness of this forms an individual's understanding of the surrounding world, an understanding of self and a potential vehicle for self-actualisation.
- Mental and intellectual development is based on building upon and expanding existing neural pathways: involving personally relevant, multi-modal associations in the pedagogical process assists in this process.
- Mental training in pedagogy can be connected to the process of interiorisation and exteriorisation: the connection between the inner and outer processes – this is dependent on the development of the whole person and the understanding by the pedagogue of this connection and how it reveals itself to each individual student.
- Mental training is based on mental imagery, which is based on the memory of surrounding environments, their synthesis, mental transformations, and juxtapositions. These images form the basis of human thought processes from the earliest of ages and form further with the cognitive, emotional and physical development of a person.

Based on these principles, the concept of mental training is viable in the pedagogical process; it re-emphasises the importance of mental processes in pedagogy and illustrates the importance of various aspects of constructivist, humanistic and activity theories.

Indeed, learning the violin is not concerned with the pure learning and repetition of a conglomeration of technical components, but directly linked to the mental and physical development of a person, which in turn is influenced by the environment in which the individual is situated.

To create a model and system for the approach and learning of violin skills based upon these holistic concepts which are at the heart of mental training, it was necessary to identify a basis of mental training. Whilst much previous literature reported the successful results of mental training, the literature in mental training did not explain exactly why it works so effectively. This thesis related mental training to the research in neuroscience, which revealed that:

1) Mental training is a manipulation of mental images and that mental imagery is used in everyday thought processes, the everyday planning of future actions and in memory retrieval;
2) Actual perception and imagery share similar brain areas.
3) An action carried out in mental imagery activates the similar brain areas as an actual, physical action.
4) The more actions are repeated, the stronger the neural connections become for those actions and that these connections also become stronger and faster also through mental imagery practice.
5) Connectivity of different imageries and neural areas: auditory perception can initiate motor imagery, visual perception of an action can initiate auditory and motor imagery, thus in turn strengthening neural connectivity of those activated areas.
6) Mirror neurons and audio-visual mirror neurons are important in the processing and mirroring of actions. They not only involve the observation and imagery of actions but also incorporate the processing of actions through the perception of the associated sound.
7) Formation of positive imagery – imagery that has positive outcomes of actions and scenarios is necessary to reduce stress and assist in positive outcomes in actual action.
8) Playing an instrument requires the combination of feedback and feedforward processes – which are based on mental imagery.
9) Instrumental playing depends on the training of the combination of auditory and motor processes in the brain.

These components, together with the interaction of theories in pedagogy, music pedagogy, psychology, developmental psychology, sports and music psychology, helped to form the basis of further the pedagogical model: the violin playing skill improvement model.

The violin playing skill components of this model were also based on the analysis and synthesis of literature in music pedagogy and, in particular, violin playing methodology.

The theoretical part of the thesis, together with the violin playing skill improvement model formed the basis of the empirical research in the second part of this thesis.

The empirical section was based on formation of the hypothesis, collecting of data and analysis of the results. Qualitative (pedagogue observations, evaluations) and quantitative methods (analysis of recordings using *Melodyne 4, Audacity*, data analysis, using spread software *Google sheets*) were employed. The tests on violin playing were carried out in the school situation – the exact locations that the students receive their lessons in school.

A mental training system was formulated to test the effectiveness of mental training on the improvement of violin skills.

The results of the testing suggest that:

- Mental training in the specialist music primary school violin pedagogical process is a viable way to introduce students to the concepts involved in violin playing and can help to improve the skill of violin playing.
- The students' techniques of violin playing improved significantly after mental training, including posture, intonation, rhythm and mixture of techniques in order to achieve dynamic contrasts and musical interpretation.
- The mental training process helps to reduce verbal instructions from the teacher and allows the student to create and find their own musical and technical solutions.
- Students gained a personally-significant way of learning that increased interest in learning and experimentation.
- The mental training exercises assisted students in becoming more aware of their own playing skill and thinking processes.
- Students became aware of the connection between the mental and the physical and the opportunity it gave them to practise the violin in the mind.
- Mental training increased the collaboration between the student and teacher.
- Students were keen to attend their lessons, and many were enthusiastic enough to arrange extra lessons, even after completion of their final exams.
- Mental training can be adapted and purposely applied in the violin teaching and learning process of young violinists.
- The mental training exercises assisted students in becoming more aware of their own playing skill, thinking processes and the concept of individual experimentation.
- Interviews with expert violin teachers confirmed that the mental training exercises and system can be utilised purposefully and effectively in the teaching and learning process of young violinists.

The mental training developed and employed in this study displayed promising results, which support the research hypothesis. Students were indeed enthusiastic to learn and had improvements in foundational violin playing skill (intonation, timing, posture) post the mental training routines. There were indications that the students were thinking ahead, imagining the sounds before producing them on the instrument and that the routines assisted in developing not only an awareness of mental imagery, but also the process of learning itself. Additionally, the research highlighted that the pedagogue also needs to think ahead, to be ready to adjust the routines and apply them according to each student's individual interests and needs.

The results of this study suggest that mental training can be adapted and purposely applied in the violin teaching and learning process of young violinists and that it helps to provide a systematic framework for developing awareness of inner, feedforward processes, and ultimately auditory-motor connections, which are at the core of violin playing.

Integrating mental training into teaching and learning processes could provide a framework for an interdisciplinary approach, the potential benefits of which perhaps also extend beyond music education, since the underlying cognitive processes are central to creativity, problem-solving, and well-being.

Theses for the defence

1) The improvement of student violin playing skill in the individualised violin teaching and learning process is determined by the interrelationship of pedagogical and psychological conditions: interest in violin playing, student individual physical and psychological attributes and the need for self-actualisation.
2) Student violin playing skill is based on the integration of mental and practical aspects identified in the violin playing skill improvement model.
3) The use of the mental training system in the pedagogical process of violin playing facilitates conscious awareness of the integration of sound and movement with musical inner hearing, as well as an awareness of the processes of interiorisation and exteriorisation in violin playing.

BIBLIOGRAPHY

1. Acharya, A. B. & Wroten, M. (2022). Broca Aphasia. In: *StatPearls* [Internet]. Florida: *Treasure Island* (FL)/ *StatPearls Publishing*; Jan 2022. Retrieved from: https://www.ncbi.nlm.nih.gov/books/NBK436010/#_NBK436010_pubdet_
2. Acredolo, C. & O' Connor, J. (1991). On the difficulty of detecting cognitive uncertainty. *Human Development*, 34(4), 204–223. https://doi.org/10.1159/000277055
3. Amaral, J. A. A. & Fregni, F. (2021). Applying Neuroscience Concepts to Enhance Learning in an Online Project-Based Learning Centred Course. *Journal of Problem Based Learning in Higher Education*, Vol. 9 No.2. https://doi.org/10.5278/ojs.jpblhe.v9i2.5892
4. Amasiatu, N. (2013). Mental Imagery Rehearsal as a psychological Technique to Enhancing Sports Performance. *Educational Research International*. Vol. 1, No. 2, p. 6977.
5. Anderson E. C., Carleton R. N., Diefenbach M. & Han P. K. J. (2019). The Relationship Between Uncertainty and Affect. *Frontiers in Psychology,* Vol. 10, 2019. https://www.frontiersin.org/articles/10.3389/fpsyg.2019.02504 https://doi.org/10.3389/fpsyg.2019.02504
6. Annett, J. (2004). mental rehearsal. In The Oxford Companion to the Mind. Oxford University Press. Retrieved 9 May. 2017 from http://www.oxfordreference.com/view/10.1093/acref/9780198662242.001.0001/acref-9780198662242-e-582
7. Atkinson, R. C. & Shiffrin, R. M. (1971). *The control processes of short-term memory*. USA: Institute for Mathematical Studies in the Social Sciences, Stanford University.
8. Armstrong, J. (2015). *Developing the Portabene Shoulder Rest By Applying the Principles of the Alexander Technique to Violin/Viola Shoulder Rest Ergonomics*. Retrieved from http://www.joearmstrong.info/ShoulderRestErgonomicsMay.html
9. Arnsten, A. F. T. & Goldman-Rakic, P. S. (1998). Noise Stress Impairs Prefrontal Cortical Cognitive Function in Monkeys Arch Gen Psychiatry. Vol. 55 No.4, p. 362–368.
10. Askland, C. (2011). *Decibel Levels and Perceived Vol. Change.* Retrieved: http://conradaskland.com/blog/decibel-levels-and-perceived-volume-change/
11. Auer, L. (1921) *Violin Playing as I Teach It*. New York. Frederick A Stokes Company.
12. Avanzino, L., Gueugneau N., Bisio A., Ruggeri P., Papaxanthis, C. & Bove, M. (2015). Motor cortical plasticity induced by motor learning through mental practice. *Frontiers in Behavioral Neuroscience,* 9,105.
13. Baker, G. (2014 a). *El Sistema: Orchestrating Venezuela's Youth.* UK: Oxford University Press.
14. Baker, G. (2014b, November 11). El Sistema: a model of tyranny? *The Guardian*. Published online. Retrieved: https://www.theguardian.com/music/2014/nov/11/geoffbakerelsistemamodeloftyranny
15. Baker, G. (2016). Editorial Introduction: El Sistema in critical perspective. *Action, Criticism, and Theory for Music Education* 15(1): 10–32.
16. Bakiri, Y., Káradóttir, R., Cossell, L. & Attwell, D. (2011). Morphological and electrical properties of oligodendrocytes in the white matter of the corpus callosum and cerebellum. *The Journal of Physiology*, 589: 559–573. https://doi.org/10.1113/jphysiol.2010.201376
17. Bandura, A. (1977). *Social Learning Theory*. New York: General Learning Press.
18. Bandura, A. (1995). Exercise of personal and collective efficacy in changing societies. In Bandura, A. (Ed.) *Self-Efficacy in Changing Societies.* New York: Cambridge University Press.
19. Bangert. M. & Schlaug, G. (2006). Specialization of the specialized in features of external human brain morphology. *European Journal of Neuroscience*, 2006 Sep;24(6), 1832–1834. https://doi.org/10.1111/j.1460-9568.2006.05031.x

20. Barbey, K. A., Koenigs, M. & Grafman, J. (2013). Dorsolateral Prefrontal Contributions to Human Working Memory. *Cortex, 49*(5), 1195–1205.
21. Barker, J., McCarthy, P., Jones, M. & Moran, A. (2011). *Single-Case Research Methods in Sport and exercise psychology*. Oxford: Routledge.
22. Barker, P. & Schaik, P. v. (2011). Mental Models and Lifelong Learning. In: N. M. Seel (Ed.) *Encyclopedia of the Sciences of Learning.* New York: Springer.
23. Bastepe-Gray, S. E, Acer N, Gumus K. Z., Gray, J. F & Degirmencioglu, L. (2020). Not all imagery is created equal: A functional Magnetic resonance imaging study of internally driven and symbol driven musical performance imagery. *Journal of Chemical Neuroanatomy*. 2020 Jan 16;104:101748. https://doi.org/10.1016/j.jchemneu.2020.101748
24. Bellesi, M., Pfister-Genskow, M., Maret, S., Keles, S., Tononi, G., & Cirelli, C. (2013). Effects of Sleep and Wake on Oligodendrocytes and Their Precursors. *The Journal of Neuroscience*, *33*(36), 14288–14300. http://doi.org/10.1523/JNEUROSCI.5102-12.2013
25. Bergonzi, L. (1997). Effects of Finger Markers and Harmonic Context on Performance of Beginning String Students. *Journal of Research in Music Education*, Vol. 45, No. 2 (Summer, 1997), pp. 197–211.
26. Blakemore, S-J. & Frith, U. (2005). *The Learning Brain*. Chichester, Wiley-Blackwell, 216 p.
27. Bolden, S. Corcoran & A. Butler (2021). A scoping review of research that examines El Sistema and Sistema-inspired music education programmes. *Review of Education*. Vol. 9, Issue 3 October 2021, https://doi.org/10.1002/rev3.3267
28. Bracha, V. & Bloedel, J. R. (2009). Motor Learning. In *Encyclopedia of Neuroscience* (pp. 2438–2441). Berlin, Heidelberg: Springer.
29. Brauns, J. (1969). *Vijoļspēles Metodika*. Rīga: Izdevniecība "Liesma."
30. Breda, J. & Kulesa, P. (1999). *Stress and Job Satisfaction among Symphony Musicians*. Symphony Orchestra Institute, Evanston, Illinois, 28 p.
31. Brooks, C. (2007). Making Waves. *Strad,* 118(1412), 55. Retrieved from http://web.b.ebscohost.com/ehost/pdfviewer/pdfviewer?vid=11&sid=3b007363-a188-4593-a22b-4a43bd0fa217%40sessionmgr103&hid=124
32. Bruner, J. S. (1961). The act of discovery. *Harvard Educational Review*, 31, 21–32.
33. Buyer, P. (2008). Mental Training in Percussion. Percussive Notes. *Journal of the Percussive Arts Society*. p. 6061.
34. Buyer, P. (2009). Mental Training in Percussion. Wisdom from the PASIC 2008 Education Committee panel discussion Percussive Notes. *Journal of the Percussive Arts Society*. April 2009, p. 3437.
35. Cannell, D., McGovern, P. & Kelly, J. (2014). *Addicts' Symphony*. TV programme, Big Mountain Productions, August 4, 2014
36. Carcillo, H. & L'Horty, Y. (2017). "Preventing Poverty Through Employment, Education and Mobility." *Notes du Conseil D'analyse économique,* 40 (4): 1–12. https://doi.org/10.3917/ncae.040.0001
37. Cha, Y-J., Yoo, E-Y., Jung, M-Y., Park, S-H, Park, J-H. & Lee, J. (2015). Effects of Mental Practice with Action Observation Training on Occupational Performance after Stroke. *Journal of Stroke and Cerebrovascular Diseases,* Vol. 24, Issue 6, June 2015, p. 1405–1413.
38. Chen, L. Penhune, V. B. & Zatorre, R. J. (2008). Listening to Musical Rhythms Recruits Motor Regions of the Brain. *Cerebral Cortex*, Vol. 18, Issue 12, pp. 2844–2854. Retrieved from http://cercor.oxfordjournals.org/content/18/12/2844.full
39. Chini, M. & Hanganu-Opatz, I. L. (2021). Prefrontal Cortex Development in Health and Disease: Lessons from Rodents and Humans. *Trends in Neurosciences.* Vol. 44, Issue 3, 2021, pp. 227–240. https://doi.org/10.1016/j.tins.2020.10.017

40. Classen, J. Liepert, S. P. Wise, M. Hallett & L. G. Cohen (1998). Rapid Plasticity of Human Cortical Movement Representation Induced by Practice. *Journal of Neurophysiology*. Vol. 79 no. 2, 1117–1123. Retrieved from http://jn.physiology.org/content/79/2/1117.full#sec-7
41. Connolly, C. & Williamon, A. (2004). Mental Skills Training. In: Williamon, A. (Ed.) *Musical Excellence: Strategies and Techniques to Enhance Performance*. Oxford: Oxford University Press.
42. Cornett, V. (2019). *The Mindful Musician: Mental Skills for Peak Performance.* New York: Oxford University Press.
43. Coro, G., Masetti, G., Bonhoeffer, P. & Betcher, M. (2019). Distinguishing Violinists and Pianists Based on Their Brain Signals. In: Tetko, I., Kůrková, V., Karpov, P., Theis, F. (eds) *Artificial Neural Networks and Machine Learning – ICANN 2019: Theoretical Neural Computation*. ICANN 2019. Lecture Notes in Computer Science, vol 11727. Springer, Cham. https://doi.org/10.1007/978-3-030-30487-4_11
44. Costandi, M. (2016). *Neuroplasticity.* Cambridge, Massachusets: The MIT Press.
45. Cotter, K. N., Christensen, A. P. & Silvia, P. J. (2019). Understanding Inner Music: A Dimensional Approach to Musical Imagery. *Psychology of Aesthetics, Creativity, and the Arts*. 2019, Vol. 13, No. 4, 489–503.
46. Dana, A. & Gozalzadeh, E. (2017). Internal and External Imagery Effects on Tennis Skills among Novices. *Perceptual and Motor Skills,* 124 (5): 1022–1043.
47. Davey, P. (2002). *Abracadabra Violin Book 1.* London: A & C Black.
48. Decety, J. (1996). Do executed and imagined movements share the same central structures? *Cognitive Brain Research*, Vol. 3, p. 87–93.
49. de Faria, O., Pivonkova, H. & Varga, B. (2021). Periods of synchronized myelin changes shape brain function and plasticity. *Nature Neuroscience,* Vol. 24, 1508–1521. https://doi.org/10.1038/s41593-021-00917-2
50. DeSantis, B., Deck, S., Hall, C. & Roland, S. (2022). Why do singers use imagery? *Research Studies in Music Education 2022, Vol. 44*(3), 527–540. https://doi.org/10.1177/1321103X221081984
51. Deverich, R. K., (2013). *Practice Makes Perfect—or Does It?* Retrieved from http://www.violinonline.com/practicetips.htm
52. de Vivo L. & Bellesi, M. (2019). The role of sleep and wakefulness in myelin plasticity. *Glia*. 2019 Nov; 67(11), 2142–2152. https://doi.org/10.1002/glia.23667
53. Dewey, J. (1897). My Pedagogic Creed. *The School Journal*, Vol. LIV, Number 3 (January 16, 1897), pp. 77–80.
54. Dewey, J. (1909). *How We Think.* London: D.C. Heath and Company.
55. Dhabhar F. S. (2018). The short-term stress response – Mother nature's mechanism for enhancing protection and performance under conditions of threat, challenge, and opportunity. *Frontiers in Neuroendocrinology*. 2018 Apr;49, pp. 175–192. https://doi.org/10.1016/j.yfrne.2018.03.004
56. Doidge, N. (2007). *The Brain That Changes Itself: Stories of Personal Triumph from the Frontiers of Brain Science*. Kindle edition Amazon Media EU S.à r.l., p. 448.
57. Doidge, N. (2015). *The Brain's Way of Healing*. New York: Penguin Group.
58. Doflein, E., Doflein, D. (1957). *The Doflein Method: The Violinist's Progress. Vol. 1. The Beginning*. London: Schott.
59. Dounis, D. C. (1925). *Violin Players' Daily Dozen to Keep the Violinist Technically Fit for the Day's Work*. New York. Harms, p. 14.
60. Dounis, D.C. (1935). *Fundamental Technical Studies on a Scientific Basis for the Young Violinist.* Philadelphia: Theodore Presser Co, p. 17.
61. Driskell, J. E., Copper, C. & Moran, A. (1994). Does Mental Practice Enhance Performance? *Journal of Applied Psychology* Vol. 79 No. 4, p. 481492.

62. Eberhardt, G. (1910) *Mein System des Übens für Violine und Klavier auf Psycho- Physiologischer Grundlage*. Dresden, Gerhard Küchtman. 2. Auflage, S. 51.
63. Eberspächer, H., (2007). *Mentales Training*. Grünwald: Corpress. Sportinform.
64. Elbert, T., Pantev, C., Weinbruch, C., Rockstroh, B. & Taub, E. (1995). Increased Cortical Representation of the Fingers of the Left Hand in String Players. *American Association for the Advancement of Science*. Science, New Series, Vol. 270, No. 5234, p. 305307.
65. Ellis, R. J., Norton, A. C., Overy, K., Winner, E., Alsop, D. C. & Schlaug, G. (2012). Differentiating maturational and training influences on fMRI activation during music processing. *Neuroimage*, 2012 Apr 15; 60(3), 1902–1912. Retrieved: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3666326/
66. Engestrom, Y. (1987). *Learning By Expanding: an activity-theoretical approach to developmental research.* Helsink: Orienta-Konsultit.
67. Fischer, S. (1997). *Basics*. London: Edition Peters.
68. Fischer, S. (2013). *The Violin Lesson.* London: Edition Peters.
69. Fishbein, M., Middlestadt, S. E., Ottati, V., Straus, S. & Ellis, A. (1987). The International Conference of Symphony and Opera Musicians Medical Questionnaire. *Senza Sordino*, 15 (6), p. 18.
70. Flavell, J. H. (1979). Metacognition and metacognitive monitoring: A new area of cognitive-developmental inquiry. The American Psychologist, 34, 906–911.
71. Fleming, S. M. & Lau, H. C. (2014). How to measure metacognition. *Frontiers in Human Neuroscience.* Vol. 8, July 2014, Article 44, pp.1–9.
72. Flohr, J. W. (2010). Best Practices for Young Children's Music Education: Guidance From Brain Research. *General Music Today*. 23(2), 13–19. Published online 4 November 2009. Retrieved from http://journals.sagepub.com/doi/abs/10.1177/1048371309352344?journalCode=gmtb
73. Floridou G. A., Peerdeman, K. J. & Schaefer, R. S. (2022). Individual differences in mental imagery in different modalities and levels of intentionality. *Memory and Cognition.* Vol. 50, 29–44 (2022). https://doi.org/10.3758/s13421-021-01209-7
74. Frank, C., Land, W. M. & Schack, T. (2016). Perceptual-Cognitive Changes During Motor Learning: The Influence of Mental and Physical Practice on Mental Representation, Gaze Behavior, and Performance of a Complex Action. *Frontiers in Psychology.* 6:1981. https://doi.org/10.3389/fpsyg.2015.01981
75. Galamian, I. (1962). *Principles of Violin Playing and Teaching*. Engelwood Cliffs: Prentice Hall.
76. Gallwey, W. T. (1974). *The Inner Game of Tennis*. New York: Random House
77. Galton, F. (1880). Statistics of Mental Imagery. *Mind*, Vol. 5, pp. 301–318.
78. Ganis, G., Thompson, A. & Kosslyn, S. M. (2004), Brain areas underlying visual mental imagery and visual perception: an fMRI study. *Cognitive Brain Research,* Vol. 20, pp. 226–241.
79. Goleman, D. & Boyatzis, R. (2008). Social intelligence and the biology of leadership. *Harvard Business Review,* Vol. 89, No. 9, pp. 74–81.
80. Gould, D. (2006). Mental Training for Young Athletes. *USA Swimming and The U.S. Ski and Snowboard Association.* Retrieved: http://cooperspurraceteam.org/wp-content/uploads/mental_training.pdf
81. Gracely, R.H., Geisser, M. E., Giesecke, T., Grant, M. A., Petzke, F., Williams, D. A., Clauw, D. J. (2004). Pain catastrophizing and neural responses to pain among persons with fibromyalgia. *Brain,* 127(4), 835–43.
82. Gray, L. A. (2019). *Educational Trauma.* In: *Educational Trauma, Examples From Testing to the School-to-Prison Pipeline.* Palgrave Macmillan, Cham. https://doi.org/10.1007/978-3-030-28083-3_2
83. Green, B. & Gallwey, W. T. (2015). *The Inner Game of Music*. Pan Books. London: Pan Macmillan.

84. Gruhn, W. (2015). How the brain plays the music A neurobiological perspective on music performance and learning. *Meakultura,* No. 257. Retrieved: http://www.meakultura.pl/publikacje/how-the-brain-plays-the-music-a-neurobiological-perspective-on-music-performance-and-learning-1349
85. Guardiola, J. & Guillen-Royo, M. (2015). Income, Unemployment, Higher Education and Wellbeing in Times of Economic Crisis: Evidence from Granada (Spain). *Social Indicators Research,* January 2015, Vol. 120, Issue 2, pp. 395–409. Retrieved from https://link.springer.com/article/10.1007/s11205-014-0598-6. https://doi.org/10.1007/s11205-014-0598-6
86. Guillot, A., Moschberger, K. & Collet, C. (2013). Coupling movement with imagery as a new perspective for motor imagery practice. *Behavioural and Brain Functions*, 2013; 9: 8. Published online 2013 Feb 20. https://doi.org/10.1186/1744-9081-9-8, http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3599464/
87. Haddon, E. (2007). What does mental imagery mean to university music students and their professors? *Department of Music, University of York, UK. International Symposium on Performance Science.* p. 301306.
88. Hale, B. & Crisfield, P. (1998). *Imagery Training: A Guide for Sports Coaches and Performers.* Arnley: Sports Coach UK, Coachwise Business solutions.
89. Hallam, S. (2006). *Music Psychology in Education.* London: Institute of Education, University of London.
90. Hannon, E.E. & Trainor, L. J. (2007). Music acquisition: effects of enculturation and formal training on development. *Trends in Cognitive Sciences*, Vol. 11, Issue 11, 2007, pp. 466–472, ISSN 1364-6613, https://doi.org/10.1016/j.tics.2007.08.008.
91. Hare, T. A. Camerer, C. F. & Rangel, A. (2009). Self-Control in Decision-Making Involves Modulation of the vmPFC Valuation System. *Science. 324*(5927), 646–648.
92. Haslinger B., Erhard P., Altenmüller E., Schroeder U., Boecker H. & Ceballos-Baumann A. O. (2005). Transmodal sensorimotor networks during action observation in professional pianists. *Journal of Cognitive Neuroscience*, Vol. 17 No. 2, pp. 282–93.
93. Haueisen J. & Knösche T. R. (2001). Involuntary motor activity in pianists evoked by music perception. *Journal of Cognitive Neuroscience*, 13 (6), pp. 786–792.
94. Hawkins, J. A. (2021). *Brain Plasticity and Learning: Implications for Educational Practice.* Cham: Palgrave Macmillan/Springer.
95. Heyes, S. B., Lau, J. Y. F. & Holmes, E. A. (2013). Mental imagery, emotion and psychopathology across child and adolescent development. *Developmental Cognitive Neuroscience, 5*, 119–133.
96. Hirsch, C. R., Mathews, A., Clark, D. M., Williams, R. & Morrison, J. A (2006). The causal role of negative imagery in social anxiety: A test in confident public speakers. *Journal of Behavior Therapy and Experimental Psychiatry*, Vol. 37, pp. 159–170.
97. Hishitani, S. (1993). Imagery differences: What controls the vividness of imagery. *Advances in Japanese Cognitive Science*, Vol. 6, p. 81117.
98. Hishitani S. (1995). Toward a deeper understanding of vividness: Some points inspired from McKelvie's Article. *Journal of Mental Imagery*, Vol. 19, pp. 139–143.
99. Hishitani S. (2011). An fMRI study of the brain area that involves suppression of mental imagery generation. *International Journal of Bioelectromagnetism,* vol. 13, No. 4, pp. 268–273.
100. Hodges, D. A. & Gruhn, W. (2019). Implications of Neurosciences and Brain Research for Music Teaching and Learning. In Gary E. McPherson, Graham F. Welch (Eds.) *Music and Music Education in People's Lives: An Oxford Handbook of Music Education, Vol. 1*, pp. 206–226. New York: Oxford University Press.
101. Hubbard, T. L. (2013). Auditory Imagery Contains More Than Audition. In: S. Lacey and R. Lawson (Eds.), *Multisensory Imagery*, pp. 221–247. New York: Springer.

102. Huijbers, W., Pennartz, C. M. A., Rubin, D.C. & Daselaar, S. M. (2011). Imagery and retrieval of auditory and visual information: Neural correlates of successful and unsuccessful performance. *Neuropsychologia 49*(2011), 1730–1740.
103. Iacoboni, M. (2009). Imitation, Empathy and Mirror Neurons. *Annual Review of Psychology,* 2009, Vol. 60, pp. 653–670.
104. Ilomäki, L. (2013). Learning from One Another's Musicianship: Exploring the Potential for Collaborative Development of Aural Skills with Pianists. In: Gaunt, H., Westerlund, H. (Ed.) *Collaborative learning in Higher Music education*. Farnham: Ashgate Publishing.
105. Ioannou, C. I., Furuya, S. & Altenmüller, E. (2016). The impact of stress on motor performance in skilled musicians suffering from focal dystonia: Physiological and psychological characteristics, *Neuropsychologia*, Vol. 85, 2016, pp. 226–236, ISSN 0028-3932, https://doi.org/10.1016/j.neuropsychologia.2016.03.029
106. Inhelder, B., Piaget, J. (1958). *The Growth of Logical Thinking from Childhood to Adolescence*. New York: Basic Books.
107. Ishibashi, T., Dakin, K.A., Stevens, B., Lee P. R., Kozlov, S. V., Stewart, C. L. & Fields, R. D. (2006). Astrocytes promote myelination in response to electrical impulses. *Neuron*. 2006 March 16;49(6), 823–832.
108. Jensenius, A. R. (2007). Action – Sound: Developing Methods and Tools to Study Music-Related Body Movement. Series of dissertations submitted to the Faculty of Humanities, University of Oslo No. 234 ISSN 0806-3222.
109. Johansen-Berg, H. (2011). How Does Our Brain Learn New Information? *Scientific American Mind* November/December 2011, p. 74.
110. Joshua, A. M. (2022). *Neuroplasticity*. In: Joshua, A.M. (eds) Physiotherapy for Adult Neurological Conditions. Springer, Singapore. https://doi.org/10.1007/978-981-19-0209-3_1
111. Julien, K. (2002). Mental Skills Training for Children and Young Athletes. *Journal of Excellence*, Issue No.7, pp. 67–75.
112. Kanno, M. (2003). Thoughts on how to play in tune: pitch and intonation. *Contemporary Music Review*, 2003, Vol. 22, Nos 1/2, 35–52.
113. Kajihara, T., Verdonschot, R. G., Sparks, J. & Stewart, L. (2013). Action-perception coupling in violinists. *Frontiers in Human Neuroscience*, *7*, 349. Retrieved from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3726832/ http://doi.org/10.3389/fnhum.2013.00349.
114. Kayser, H. E. (c.1865) *Neueste Methode des Violinspiels*, *Op.32.* Hamburg, Aug. Cranz. S.136.
115. Keen, R. (2011). The Development of Problem Solving in Young Children: A Critical Cognitive Skill. *Annual Review of Psychology, 62*, 1–21.
116. Keller, P. E. (2012). Mental imagery in music performance: underlying mechanisms and potential benefits. *Ann. N.Y. Acad. Sci.* 1252 (2012) 206–213.
117. Kempter, S. (2003). *How Muscles Learn: Teaching Violin With The Body In Mind*. London: Alfred Music.
118. Kent, M. (2006). External imagery. In The Oxford Dictionary of Sports Science & Medicine. Oxford University Press. Retrieved 9 May. 2017, from http://www.oxfordreference.com/view/10.1093/acref/9780198568506.001.0001/acref-9780198568506-e-2457
119. Keysers, C., Kohler, E, Umiltà, M. A., Nanetti, L., Fogassi, L. & Gallese V. (2003). Audiovisual mirror neurons and action recognition. *Experimental Brain Research*, 2003 Dec;153(4), 628–636. Epub 2003 Aug 23
120. Keysers, C. (2009). Mirror Neurons. *Current Biology,* Vol 19, No. 21. pp. R971-R973.
121. Klöppel, R. (2010). *Mentales Training für Musiker*. Kassel: Gustav Bosse Verlag GmbH.
122. Kohler, E., Keysers, C., Ulmit, A., Fogassi, L., Gallese, V., Rizzolatti, G. (2002). Hearing Sounds, Understanding Actions: Action Representation in Mirror Neurons. *Science,* Vol. 297, 02 August

2002, pp. 846–848. Retrieved: http://old.unipr.it/arpa/mirror/pubs/pdffiles/Kohler-Keysers%20 2002.pdf

123. Kolb, D. A. (1984). *Experiential learning. Experience as the source of learning and development*. New Jersey: Prentice Hall.
124. Kolb A. Y. & Kolb, D. A. (2012). Experiential Learning Theory. In: N. M. Seel (Ed.) *Encyclopedia of the Sciences of Learning.* New York: Springer.
125. Kolb, A., & Kolb, D. (2018). Eight important things to know about the experiential learning cycle. *Australian Educational Leader*, *40*(3), 8–14. https://search.informit.org/doi/10.3316/informit.192540196827567
126. Kosslyn, S., Seger, C., Pani, J. R. & Hilliger, L. A. (1990). When Is Imagery Used In Everyday Life? A Diary Study. *Journal of Mental Imagery*, 1990, Vol. 14, p. 131152.
127. Kosslyn, S., Behrmann, M. & Jeannerod, M. (1995). The Cognitive Neuroscience of Mental Imagery. *Neuropsychologia*, Vol. 33, No. 11, pp. 1355–1344.
128. Kozulin, A. (2003). *Vygotsky's Educational Theory in Cultural Context.* Cambridge: Cambridge University Press.
129. Langley, M. R., Triplet E. M. & Scarisbrick I. A. (2020). Dietary influence on central nervous system myelin production, injury, and regeneration. *Biochim Biophys Acta Mol Basis Dis*. 2020 Jul 1;1866(7):165779. https://doi.org/10.1016/j.bbadis.2020.165779
130. Leontiev, A. N. (1977). *Activity and Consciousness.* Retrieved: https://www.marxists.org/archive/leontev/works/activity-consciousness.pdf
131. Lewin, R. (1974). The Poverty of Undernourished Brains. *New Scientist,* 64, 268–271.
132. Liikkanen, L. A. (2008). Music in Everymind: Commonality of Involuntary Musical Imagery. *Proceedings of the 10th International Conference on Music Perception and Cognition (ICMPC 10)*. Sapporo, Japan
133. Linde-Domingo, J., Treder, M.S. & Kerrén, C. (2019). Evidence that neural information flow is reversed between object perception and object reconstruction from memory. *Nat Commun 10, 179 (2019)*. https://doi.org/10.1038/s41467-018-08080-2
134. Li, B.–Z. Nan, W. Pun, S. H. Vai, M.I., Rosa, A. & Wan, F. (2023) Modulating Individual Alpha Frequency through Short-Term Neurofeedback for Cognitive Enhancement in Healthy Young Adults. Brain Sci. 2023, 13, 926. https://doi.org/10.3390/brainsci13060926
135. Li-Wei, Z., Qui Wei, M., Orlick, T. & Zitzelsbeger, L. (1992). The Effect of Mental Imagery Training on Performance Enhancement With 7–10 Year Old Children. *The Sport Psychologist*, 1996, 6, pp. 230–241.
136. Lotfi, G., Tahmasbi, F., Forghani, M. H. & Szwarc, A. (2020). Effect of positive and negative dimensions of mental imagery and self-talk on learning of soccer kicking skill. *Physical Education of Students. December 2020.* https://doi.org/10.15561/20755279.2020.0603
137. Lotze, M., Scheler, G., Tan, H-R. M., Braun, C. & Birbaumera, N. (2003). The musician's brain: functional imaging of amateurs and professionals during performance and imagery. *NeuroImage* 20 (2003), 1817–1829.
138. Luria, A. (1968). *The Mind of a Mnemonist.* New York: Basic Books.
139. Mack, G., Casstevens, D. (2001). *Mind Gym: An Athlete's Guide to Inner Excellence*. New York: McGrawHill.
140. Maddock, R. J., Garrett, A. S. & Buonocore, M. H. (2003). Posterior Cingulate Cortex Activation by Emotional Words: fMRI Evidence From a Valence Decision Task. *Human Brain Mapping*, Vol. 18, No.1, pp. 30–41
141. Maine Dept. of Labor, Labor Market Information Services (n.d.) *The Relationship Between Education and Unemployment and Earnings* http://www.maine.gov/labor/cwri/publications/pdf/EducationUnemploymentEarnings.pdf

142. Marion, G., Di Liberto, G. M. & Shamma, S. A. (2021). The Music of Silence: Part 1: Responses to Musical Imagery Encode Melodic Expectations and Acoustics. *The Journal of Neuroscience*, September 1, 2021 41(35), 7435–7448. https://doi.org/10.1523/JNEUROSCI.0183-21.2021
143. Mark. M. L. & Madura, P. (2013). *Contemporary Music Education 4th Edition.* USA: Cengage Learning.
144. Martin, M. E. (2004). *14 Steps Toward Improved Intonation*. Retrieved from http://stringsmagazine.com/14-steps-toward-improved-intonation/
145. Maslow, A. H. (1943). A Theory of Human Motivation. *Psychological Review*, 50, 370–396.
146. Mastin, L. (2010). *Short-Term (Working) Memory*. Retrieved from http://www.human-memory.net/types_short.html
147. Matsudaira I, Yokota S, Hashimoto T, Takeuchi H, AsaNo. K & AsaNo. M. (2016). Parental Praise Correlates with Posterior Insular Cortex Gray Matter Vol. in Children and Adolescents. *PLoS ONE*, Vol. 11(4): e0154220. https://doi.org/10.1371/journal.pone.0154220
148. Mayer, J. & Hermann, H. D. (2011). *Mentales Training*. Berlin: Springer.
149. Mayford, M., Siegelbaum, S. A & Kandel, E. R. (2012). Synapses and memory storage. *Cold Spring Harb Perspect Biol.* 1;4(6):a005751. https://doi.org/10.1101/cshperspect.a005751
150. McCrum, R. (2016). 'Perfect mind': On Shakespeare and the brain. *Brain*, 139(12), 3310–3313. https://doi.org/10.1093/brain/aww279
151. Mcleod, S. (2014). *Lev Vygotsky.* Retrieved from https://www.simplypsychology.org/vygotsky.html
152. McKenzie, I. A., Ohayon, D., Li, H, de Faria, J. P., Emery, B., Tohyama, K. & Richardson, W. D. (2014). Motor skill learning requires active central myelination. *Science*. 2014 Oct 17;346(6207), 318–322. Retrieved from https://www.ncbi.nlm.nih.gov/pubmed/25324381 https://doi.org/10.1126/science.1254960
153. McPherson, G. E. (2005). From child to musician: skill development during the beginning stages of learning an instrument. *Society for Education, Music and Psychology Research*, *Psychology of Music*, *33*(1), 5–35. https://doi.org/10.1177/0305735605048012.
154. Milbocker, K. A., Campbell, T. S., Collins, N., Kim, S., Smith I. F., Roth T. L. & Klintsova A. Y. (2021). Glia-Driven Brain Circuit Refinement Is Altered by Early-Life Adversity: Behavioral Outcomes. *Frontiers in Behavioral Neuroscience.* Vol. 15, 2021. https://doi.org/10.3389/fnbeh.2021.786234
155. Miller, G. (1956). The magical number seven, plus or minus two: Some limits on our capacity for processing information. *The psychological review*, 63, 81–97.
156. Mizuguchi, N., Nakata, H., Uchida, Y. & Kanosue, K. (2012). Motor Imagery Sport Performance. *The Journal of Physical Fitness Sports Medicine* 1(1), 103–111 (2012). https://doi.org/10.7600/jpfsm.1.10
157. Moran, A. & O'Shea, H. (2020). Motor Imagery Practice and Cognitive Processes. *Frontiers in Psychology, 2020, Vol. 11, article 394*. https://doi.org/10.3389/fpsyg.2020.00394
158. Morris, T., Spittle, M. & Watt, A. (2005). *Imagery in Sport*. Champaign: Human Kinetics.
159. Motoyama, H. & Hishitani, S. (2016). The Brain Mechanism that Reduces the Vividness of Negative Imagery. *Consciousness and Cognition.* Vol. 39, January 2016, pp. 59–69. https://doi.org/10/1016/j.concog.2015.11.006
160. Mulder, T, Hochstenbach, J., Zijlstra, W. & Zijlstra, S. (2004). The role of motor imagery in learning a totally novel movement. *Experimental Brain Research,* https://doi.org/10.1007/s00221-003-1647-6
161. Nanay, B. (2018). Multimodal Mental Imagery. *Cortex.* Vol. 105, August 2018, pp. 125–134.
162. Nanay, B. (2021). Unconscious Mental Imagery. Philosophical Transactions B 376:20190689. https://doi.org/10.1098/rstb.2019.0689

163. Nielsen, F. A., Balsev, D. & Hansen, L. K. (2005). Mining the Posterior Cingulate: Segregation between Memory and Pain Components. Neuroimage 27 (2005), 520–532. https://doi.org/10.1016/j.neuroimage.2005.04.034
164. Orlick, T. & McCaffrey, N. (1991). Mental Training for Children for Sport and Life. *The Sport Psychologist*, Vol. 5, pp. 322–334
165. Ozernov-Palchik, O. & Patel, A. D. (2018), Musical rhythm and reading development: does beat processing matter? *Ann. N.Y. Acad. Sci.*, Vol. 1423, 166–175. https://doi.org/10.1111/nyas.13853
166. Palva, S. & Palva, J. M. (2007). New vistas for alpha-frequency band oscillations. *Trends Neurosci*ences. 2007 Apr; 30(4), 150–158.
167. Pascuale-Leone, A., Nguyet, D., Cohen, L. G., Brasil-Neto, J. P., Cammarota, A. & Hallett, M. (1995). Modulation of muscle responses evoked by transcranial magnetic stimulation during the acquisition of new fine motor skills. *Journal of Neurophysiology.* September 1995, 74(3), 1037–1045.
168. Pascuale-Leone, A., Amedi, A., Fregni, F. & Merabet, L. B. (2005). The Plastic Human Brain Cortex. *Annual Review of Neuroscience*. 2005. 28:377–401. Published online. Retrieved from http://multisensory.ekmd.huji.ac.il/publications/Pascual-Leone_Amedi_et%20al%20Ann%20Rev%20Neurosci%2005.pdf, https://doi.org/10.1146/annurev.neuro.27.070203.144216
169. Pearson, J. (2019). The human imagination: the cognitive neuroscience of visual mental imagery. *Nat Rev Neurosci 20,* 624–634 (2019). https://doi.org/10.1038/s41583-019-0202-9
170. Pellegrino, G., Fadiga, L., Forgassi, L., Gallese, V. & Rizzolati, G. (1992). Understanding motor events: a neurophysiological study. *Experimental Brain Research*, Vol. 91, pp. 176–180.
171. Peters, M. A. (2011). Forward. In Patten, K. E., Campbell, S. R. *Educational Neuroscience.* Chichester, Wiley-Blackwell, pp. xi-xii.
172. Perry, B. D. (2006). Fear and Learning: Trauma-Related Factors in the Adult Education Process. *New Directions for Adult and Continuing Education* Vol. 2006 (110), 21–27. https://doi.org/10.1002/ace.215.
173. Piaget, J. (1973). *Main Trends in Psychology (Main Trends in the Social Sciences).* London: Allen and Unwin.
174. Pillay, S. (2011). *Your Brain and Business: The Neuroscience of Great Leaders.* New Jersey: Person Education.
175. Plakke, B. & Romanski, L. M. (2014). Auditory connections and functions of prefrontal cortex. *Frontiers in Neuroscience*, 2014 Jul 23;8:199. Retrieved from https://www.ncbi.nlm.nih.gov/pubmed/25100931, https://doi.org/10.3389/fnins.2014.00199, eCollection 2014.
176. Pecher, D., Boot, I., & Van Dantzig, S. (2011). Abstract concepts: Sensory-motor grounding, metaphors, and beyond. In B. Ross (Ed.). *The Psychology of Learning and Motivation*, vol. 54, pp. 217–248. Burlington: Academic Press.
177. Podolskiy, A. (2011). Cultural-Historical Theory of Development. In: N. M. Seel (Ed.) *Encyclopedia of the Sciences of Learning.* New York: Springer.
178. Pressley, G. M. (1976). Mental imagery helps eight-year olds remember what they read. *Journal of Educational Psychology*, 68(3), 355–359, June 1976.
179. Purves D. & Augustine, G. J. (2001). Increased Conduction Velocity as a Result of Myelination. In D. Fitzpatrick (Ed.) *Neuroscience*. 2nd edition. Sunderland: Sinauer Associates. Retrieved from: https://www.ncbi.nlm.nih.gov/books/NBK10921/
180. Pykett, J. (2015). *Teaching the learning brain: Shaping policy through neuroscience*. Bristol: Policy Press.
181. Reiniger, H., Cort, J., (2005, January 25). Mirror Neurons. PBS. Retrieved: http://www.pbs.org/wgbh/nova/body/mirror-neurons.html

182. Richardson, A. (1967). Mental Practice: A Review and Discussion Part I. *Research Quarterly. American Association for Health, Physical Education and Recreation.* Vol. 38, Issue 1, pp. 95–107.
183. Riley-Tillman, T. S. & Burns, M. K. (2009). *Evaluating Educational Interventions Single-Case Design for Measuring Response to Intervention.* New York: The Guilford Press.
184. Rizzolatti, G. & Craighero, L. (2004). The Mirror Neuron System. *Annual Review of Neuroscience*, 2004. Vol. 27, pp. 169–192.
185. Rolla, A. (1814). *Ventiquattro Scale per il Violino*. Milan, Giovanni Ricordi.
186. Rogers, C. (1951). *Client-centered therapy: Its current practice, implications and theory*. London: Constable.
187. Rogers, C. (1961). *On Becoming a Person*. Boston: Houghton Mifflin.
188. Rubin-Rabson, G. (1941). Studies in the psychology of memorizing piaNo. music. VI: A comparison of two forms of mental rehearsal and keyboard overlearning. *Journal of Educational Psychology,* Vol 32(8), pp. 593–602.
189. Saban, A. (2008). Primary School Teachers' and Their Students' Mental Images About the Concept of Knowledge. *Elementary Education Online, 7(2), 421–455, 2008*
190. Sackett, R. S. (1934). The influence of symbolic rehearsal upon the retention of a maze habit. *Journal of General Psychology*, Vol 10, Issue 2, pp. 376–398.
191. Sadoski, M. (1985). The Natural Use of Imagery in Story Comprehension and Recall:Replication and Extensio. *Reading Research Quarterly*, Vol. 20, No. 5, p. 658667.
192. Saintilan, P. (2020). *Musicians and Addiction.* Sydney: Music Australia. eBook, p. 366. ISBN 9780648688303
193. Salzberg, R. S. (1980). The effects of visual stimulus and instruction on intonation accuracy of stringed instrumentalists. *Psychology of Music*, Vol 8, Issue 2, pp. 42 – 49. Retrieved from http://journals.sagepub.com/doi/abs/10.1177/030573568082005?journalCode=poma
194. Palomar-García, M. A., Zatorre, R. J., Ventura-Campos, N., Bueichekú, E. & Ávila, C. (2016). Modulation of Functional Connectivity in Auditory–Motor Networks in Musicians Compared with Nonmusicians. *Cerebral Cortex* (2017) 27 (5), 2768–2778. First published online: May 10, 2016. Retrieved: https://academic.oup.com/cercor/article/27/5/2768/3056341/Modulation-of-Functional-Connectivity-in-Auditory
195. Sarasso, C., Gemma, M., Agosta, F., Filippi, M. & Gatti, R. (2015). Action observation training to improve motor function recovery: a systematic review. *Archives of Physiotherapy* (2015) 5:14 https://doi.org/10.1186/s40945-015-0013-x
196. Scherber, R. V. (2014). *Pedagogical Practices Related to the Ability to Discern and Correct Intonation Errors: An Evaluation of Current Practices, Expectations, and a Model for Instruction.* Doctoral dissertation, Florida State University College of Music, Florida, USA.
197. Schottky, J. M. (1830). *Paganini's Leben und Treiben als Künstler und als Mensch, mit unpartheiischer Berücksichtigung der Meinungen seiner Anhänger und Gegner.* Prag: J. G. Calvesche.
198. Schunk, D. H. (2014). Theories of Learning. In: Phillips, D. C. (Ed.), *Encyclopedia of Educational Theory and Philosphy,* pp. 466–470. California: Sage Publications Inc.
199. Schwenkreis, P., Tom, S. E., Ragert, P. Pleger, B., Tegenthoff, M. & Dinse, H., R. (2007). Assessment of Sensorimotor Cortical Representation Asymmetries and Motor Skills in Violin Players. *European Journal of Neuroscience.* Vol. 26, 3291–3302
200. Seaton, R, Sharp, D., Jones, A. & Pim, D. N. (2016). Experiments with Choirs – Practice and Pitfalls. In: *Proceedings of the Institute of Acoustics*, Institute of Acoustics, St. Albans, pp. 362–373. Retrieved from http://oro.open.ac.uk/47836/1/Seaton%20Experiments%20with%20Choirs.pdf
201. Seidel, B. (2008). *Picture Yourself Playing the Violin.* Boston: Thomson Course Technology.

202. Shen, J. (2013). *Why Practice Actually Makes Perfect: How to Rewire Your Brain for Better Performance*. Retrieved from https://blog.bufferapp.com/why-practice-actually-makes-perfect-how-to-rewire-your-brain-for-better-performance#footnotes
203. Short, S. E., Affremow, J. & Overby, L. (2001). Using Mental Imagery to Enhance Children's Motor Performance. *Journal of Physical Education, Recreation & Dance*. 72(2), pp. 19–23.
204. Spohr, L. (1832). *Violinschule*. Wien: Thobias Haslinger.
205. Špona, A. Čamane, I. (2009). *Audzināšana Pašaudzināšana*. Riga: Izdevniecība Raka.
206. Stergiou, M., Raheb, K. & Ioannidis, Y. (2019). Imagery and metaphors: from movement practices to digital and immersive environments. In: *Proceedings of the 6th International Conference on Movement and Computing* (MOCO '19). Association for Computing Machinery, New York, NY, USA, Article 18, 1–8. https://doi.org/10.1145/3347122.3347141
207. Sugio, S., Daisuke, Kato, D. & Wake, H. (2022). Myelinated axon as a plastic cable regulating brain functions. *Neuroscience Research,* 2022, article in press https://doi.org/10.1016/j.neures.2022.11.002
208. Suzuki, S. (1978). *Violin. Violin Part. Vol. One.* Miami: Summy-Birchard.
209. Suzuki, S. (1998). *Sinichi Suzuki: His Speeches and Essays*. Miami: Summy Birchard.
210. Sullivan, K. J., Kantak, S., Burtner, P. A. (2008). Motor Learning in Children: Feedback Effects on Skill Acquisition. *Physical Therapy,* 88(6), 720–32.
211. Swinnen, S. P., Schmidt, R. A., Nicholson, D. E. & Shapiro, D. C. (1990). Information Feedback for Skill Acquisition: Instantaneous Knowledge of Results Degrades Learning. *Journal of Experimental Psychology, Learning, Memory and Cognition.* 1990, Vol. 16, No. 4, 706–716.
212. Tarnow, E. (2009). Short term memory may be the depletion of the readily releasable pool of presynaptic neurotransmitter vesicles of a metastable long term memory trace pattern. *Cognitive Neurodynamics*, *3*(3), 263–269. https://doi.org/10.1007/s11571-009-9085-1
213. Thamizhoviya, G., Kirjayini, P. P. & Vanisree, A. J. (2017). Impact of noni juice on myelin components, neurotransmittory and behavioural status in rats exposed to immobilization stress. *Current Science*, Vol. 112, No. 2, 25 January 2017.
214. Thomas, Nigel J. T. (2016). Mental Imagery. In E. N. Zalta (Ed.), *The Stanford Encyclopedia of Philosophy* (Summer 2016 ed.). Retrieved from <http://plato.stanford.edu/archives/sum2016/entries/mentalimagery/> .
215. Thunnissen M. R., Nauta M. H., de Jong, P. J., Rijkeboer M. M. & Voncken M. J. (2022). Flashforward imagery in speech anxiety: Characteristics and associations with anxiety and avoidance. *Frontiers in Psychology,*Vol. 13, 2022. https://doi.org/10.3389/fpsyg.2022.975374
216. Targonskis, J. & Sturesteps, V. (1960). *Vijoles Spēles Skola*. Rīga: Latvijas Valsts Izdevniecība.
217. Toth, A. J., McNeill, E., Hayes, K. & Moran A. P. & Campbell, M. (2020). Does mental practice still enhance performance? A 24 Year follow-up and meta-analytic replication and extension. *Psychology of Sport and Exercise*, Vol. 48, 2020, 101672, ISSN 1469-0292, https://doi.org/10.1016/j.psychsport.2020.101672.
218. Trinity College London Strings Syllabus (2014). Bowed Strings and Harp Grade exams 2015. Trinity College, London. Retrieved from https://www.trinitycollege.com/resource/?id=4696
219. Yurgelun-Todd, D. (2007). Emotional and cognitive changes during adolescence. *Current Opinion in Neurobiology*, 17, 251–257.
220. Vellema, M., Diales Rocha, M., Bascones, S., Zsebők, S., Dreier, J., Leitner, S., Van der Linden, A., Brewer, J., & Gahr, M. (2019). Accelerated redevelopment of vocal skills is preceded by lasting reorganization of the song motor circuitry. *eLife*, *8*, e43194. https://doi.org/10.7554/eLife.43194
221. Vanderauwera, J., van Setten, E. R. H., Maurits, N., M. & Maasen, B. A. M. (2019). The interplay of socio-economic status represented by paternal education level, white matter structure and reading. *Plos ONE,* 14(5), e0215560.

222. van Duijvenvoorde, A. C. K., Whitmore, L. B., Westhoff, B. & Mills, K. L. (2022). A methodological perspective on learning in the developing brain. *npj Science of Learning*. 7, 12 (2022). https://doi.org/10.1038/s41539-022-00127-w
223. Vulliamy, E. (2010) Strings attached: what the Venezuelans are doing for British kids. *The Guardian Observer.* Published online 3 October 2010. Retrieved from https://www.theguardian.com/education/2010/oct/03/britain-children-orchestra-sistema
224. Vygotsky, L. (1930). The Instrumental Method in Psychology. Text of a talk given at the Krupskaya Academy of Communist Education. Retrieved from https://www.marxists.org/archive/vygotsky/works/1930/instrumental.htm
225. Vygotsky L. (1978). *Mind in Society*. USA: Harvard University Press.
226. Wakin, D. J. (2012, 15th February). Fighting Poverty, Armed With Violins. *The New York Times,* p. C1. Published online 15 February 2012. Retrieved from http://www.nytimes.com/2012/02/16/arts/music/el-sistema-venezuelas-plan-to-help-children-through-music.html
227. Wan, C. Y. & Schlaug, G. (2010). Music Making as a Tool for Promoting Brain Plasticity across the Life Span. Neuroscientist, 2010 Oct; 16(5), 566–577. Retrieved from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2996135/
228. Winerman, L. (2005). A new type of neuron--called a mirror neuron--could help explain how we learn through mimicry and why we empathize with others. *Monitor Staff*, October 2005, Vol 36, No. 9 Print version: page 48. Retrieved from http://www.apa.org/monitor/oct05/mirror.aspx
229. Williamson, V. J. & Jilka, S. R. (2014). Experiencing earworms: An interview study of Involuntary Musical Imagery. *Psychology of Music*, 42(5), 653–670. https://doi.org/10.1177/0305735613483848
230. Willis, J. (2006). *Research-Based Strategies to Ignite Student Learning. Insights from a Neurologist and Classroom Teacher*. USA: Alexandria, ASCD.
231. Wolfe, P. (2010). *Brain Matters: Translating Research into Classroom Practice*. USA, Alexandria, ASCD.
232. Wohlfahrt, F. (1882). Etude Op. 45, No. 37. In: Herfurth, C. P. (Ed.) A Tune a Day for Violin: Book 3. London: Chappell and Co LTD.
233. Woo E, Sansing L. H., Arnsten A. F. T. & Datta D. (2021). Chronic Stress Weakens Connectivity in the Prefrontal Cortex: Architectural and Molecular Changes. *Chronic Stress*. 2021, Vol. 5. https://doi.org/10.1177/24705470211029254
234. Woolfolk, R. L., Parrish, M. W. & Murphy, S. M. (1985). The Effects of Positive and Negative and Positive Imagery on Motor Skill Performance. *Cognitive Therapy and Research,* Vol. 9 No.3, 1985, p. 335341.
235. Yates, F. (1966). *The Art of Memory*. London: Routledge.
236. Yohn, N. & Blendy, J. A. (2017). Adolescent Chronic Unpredictable Stress Exposure Is a Sensitive Window for Long-Term Changes in Adult Behavior in Mice. *Neuropsychopharmacology*, (2017), pp. 1–9.
237. Zatorre, R. J., Chen, J. L & Penhune, V. B. (2007). When the brain plays music: auditory–motor interactions in music perception and production. *Nature Reviews, Neuroscience*, Vol. 8, July 2007, pp. 547–558.
238. Zatorre, R. J., Fields R. D. & Johansen-Berg, H. (2012). Plasticity in Grey and White: Neuroimaging changes in brain structure during learning. *Nature Neuroscience* 15, 528–536 (2012), Published online 18 March 2012. Retrieved from http://www.nature.com/neuro/journal/v15/n4/full/nn.3045.html, https://doi.org/10.1038/nn.3045
239. Zatorre, R. J. & Halpern, A. R. (2005). Mental Concerts: Musical Imagery and Auditory Cortex. *Neuron*, Vol. 47, 9–12, July 7, 2005.
240. Zdzinski, S. F. &Barnes, G. V. (2002). Development and Evaluation of a String Performance Assessment Scale. *Journal of Research in Music Education*, 2002, Vol. 50, No. 3, pp. 245–255.

241. Xin, W. & Chan, J. R. (2020). Myelin plasticity: sculpting circuits in learning and memory. *Nature reviews. Neuroscience*, 21(12), 682–694. https://doi.org/10.1038/s41583-020-00379-8

Other sources

1. Abreau, J.A. & Dudamel, G. (2009). *El Sistema – Music to Change Life*. [DVD]. Medici Arts. 109 minutes.
2. Armstrong, J. D. [The University of Edinburgh] (2013, 19th Feb). *Prof. J Douglas Armstrong – Systems Neuroscience.* Retrieved from: https://www.youtube.com/watch?v=WSNqjrNA3OQ
3. GIMLPublications (2011). *Music Learning Theory Practical Applications Part 6.* https://www.youtube.com/watch?v=zeLyAtNO2Lc
4. Mackenzie, B. (2001). *Skill, Technique and Ability.* Retrieved from: https://www.brianmac.co.uk/skills.htm
5. Mutter, A. S. (2015). *Meet the Pros: Anne-Sophie Mutter Interview.* Retrieved: https://www.youtube.com/watch?v=FmBdo9JkTuo
6. Sassmannshaus, K. (2012a). *Intonation: Just Intonation*. Retrieved from https://www.youtube.com/watch?v=JfnfXnlKJ5I
7. Sassmannshaus, K. (2012b). *Intonation: Pythagorean Intonation*. Retrieved from https://www.youtube.com/watch?v=buZOs-czOUg
8. Sassmannshaus, K. (2012c). *Intonation: Which System to Use When.* Retrieved from https://www.youtube.com/watch?v=QaYOwIIvgHg&index=2&list=RDbuZOs-czOUg
9. Vengerov, M., Barenboim, D. & Broughton, S. (2008) Maxim Vengerov: Playing By Heart & Masterclass, KULTUR VIDEO, 100 minutes.
10. Zukerman, P. (2014). *Pinchas Zukerman: Violin / Viola Masterclass 2014*. Retrieved from: https://www.youtube.com/watch?v=0A1gFKNCa3I

APPENDIX

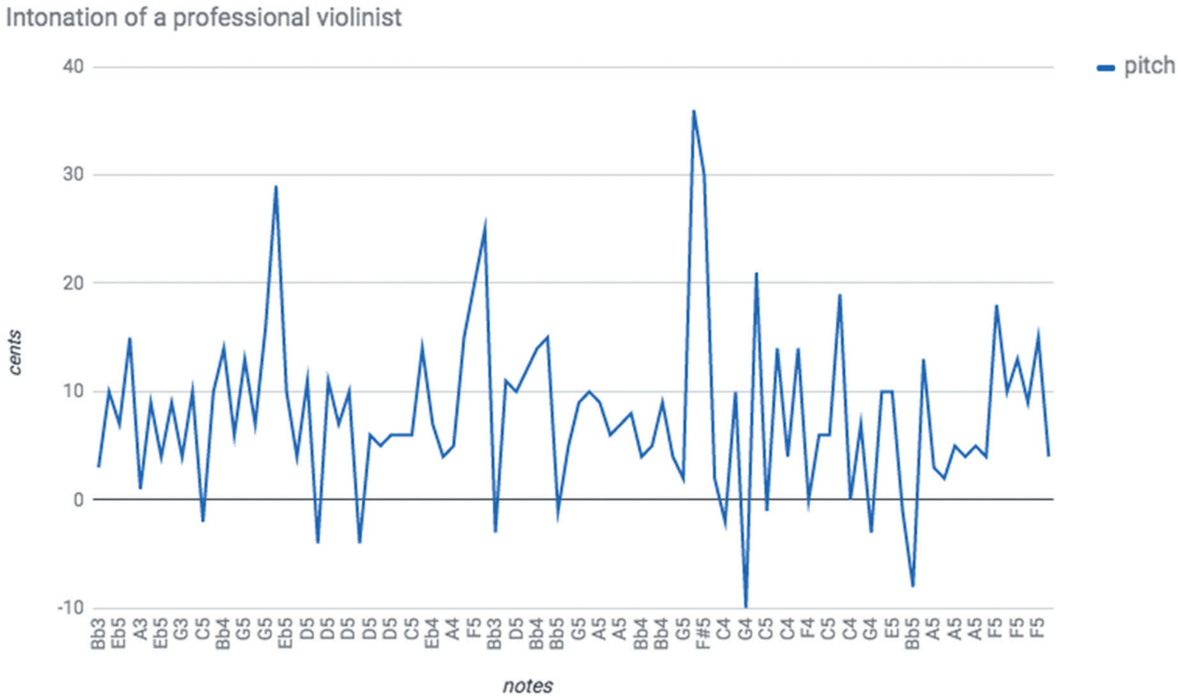
Contents

1. STUDENT EVALUATION CARD

CRITERIA								
	Musical text	Rhythm	Posture			Tone quality	Dynamics	Characters, emotions, musical expression
Student	Intonation, fingering	Bow division	Left hand	Right hand	Whole body	Sound points	Dynamic contrast	mixture
1								
2								
3								
4								
5								
6								
7								
8								
9								

2. ANALYSIS OF THE INTONATION OF A PROFESSIONAL VIOLINIST

Graphic illustration of the range of intonation by a professional violinist playing Telemann Fantasia in B*flat* major.



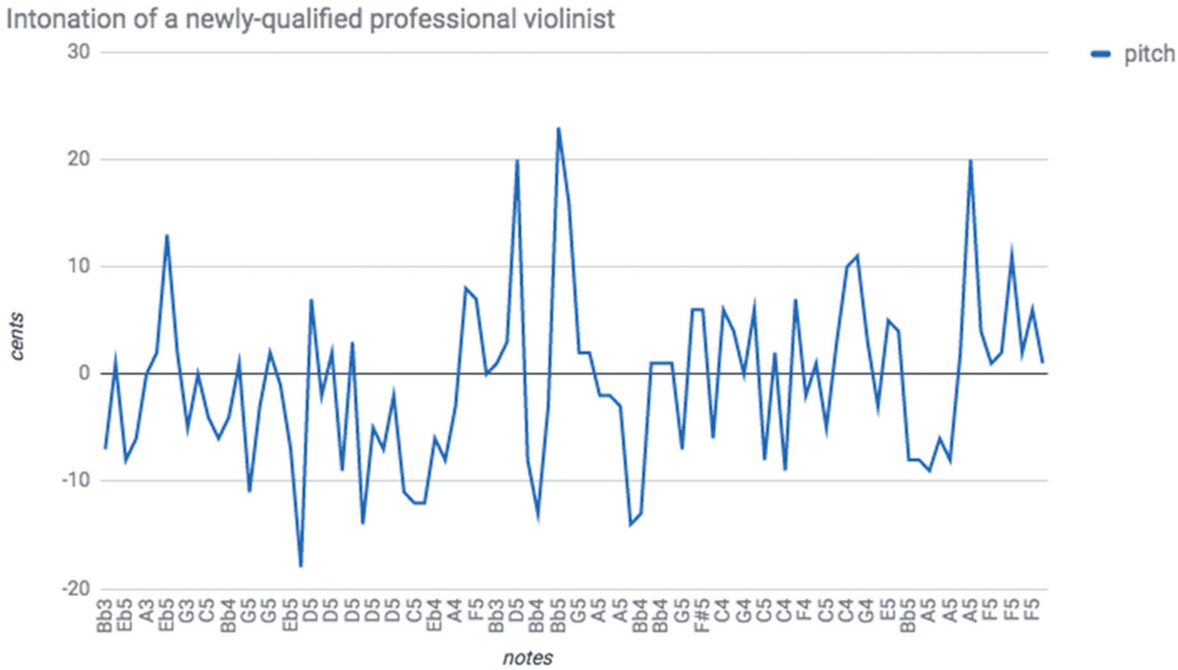
This recording seems accurately represent professional playing, since very few notes fall far below equal temperament and leading notes are generally raised.

Range of intonation

Minimum	–10
Maximum	36
Range	46
Interquartile range	7

3. ANALYSIS OF THE INTONATION OF A NEWLY-QUALIFIED PROFESSIONAL VIOLINIST

Graphic illustration of the range of intonation by a newly-qualified professional violinist playing Telemann Fantasia in B*flat* major analysed from a recording publicly available on youtube.com.



Interestingly, this newly-qualified professional violinist has an overall range of 41, which is within the criteria identified in this study as being acceptable for intonation, however many notes appear below the zero line of equal temperament, including the third degree of the scale (D) and the leading note (A), which according to Pythagorean intonation could be raised, rather than being lower than equal temperament. This is rarely seen in mainstream, commercially available recordings. This suggests that newly-qualified professional violinists may still be developing their auditory-motor connection, or that the concrete concepts of intonation used in violin playing are not routinely taught in conservatoire situations; that concepts of intonation may be gained intuitively, rather than purposefully in the pedagogical process. More research could be carried out in this area.

Range of intonation

Minimum value	–18
Maximum value	23
Overall range	41
Interquartile range	9.25

4. FRANZ WOHLFAHRT ETUDE OP. 74, NO. 5, EXCERPT

Excerpt of an etude played by student 2 (Wohlfahrt, 1936, 5)

5. DATA FROM THE FIRST USE OF MENTAL TRAINING

Student 1			Student 2			Student 3		
Pitches	Before (cents)	After (cents)	Pitches	Before (cents)	After (cents)	Pitches	Before (cents)	After (cents)
Bb3	27	28	A3	−18	−43	D4	2	−2
C4	14	−16	C4	−21	−26	F#4	11	43
D4	3	2	F4	38	27	E4	−5	−8
Eb4	23	23	A4	8	−1	D4	0	0
F4	29	30	C5	17	38	E4	−35	−20
G4	−10	17	F5	69	20	F#4	−1	16
A4	4	16	A5	−33	0	G4	20	0
Bb4	−3	5	G#5	−59	33	A4	5	0
A4	−11	17	Bb5	16	−2	B4	−29	−22
Bb	−4	10	A5	−68	−15	C#5	16	18
A4	−8	12	F4	187	20	D5	−17	−18
G4	−10	16	D5	−55	−16	F#5	116	50
A4	7	19	C5	−15	18	G5	−42	66
Bb	−19	11	B5	132	−12	A5	−43	−29
C5	−100	9	D5	−45	−31	B5	−38	−61
A4	4	27	C5	−5	20	C#6	136	−97
Bb4	−1	28	A4	5	−1	D6	−28	−96
C5	1	13	F4	13	4	C#6	126	−101
D5	−15	15	C4	−46	−24	B5	3	−68
Eb5	121	115	B	−85	−30	A5	152	−57
F5	−13	47				G5	76	60
G5	−36	−14				F#5	−18	−10
A5	−11	23				E5	62	0
Bb5	76	67				D5	29	26
C6	−9	66				C#5	25	24
Bb5	106	72				B4	−22	−24
A5	−9	39				A4	14	3
Bb5	103	109				G4	3	24
C6	−5	68				F#4	23	32
D6	8	49				E4	9	−15
						D4	1	0

Student 4			Student 5		
Pitches	**Before**	**After**	**Pitches**	**Before**	**After**
A3	−13	8	**D4**	0	0
D4	−2	−2	**G4**	−21	39
F4	46	27	**D4**	0	3
A4	0	1	**D4**	4	1
D5	41	−10	**G4**	−37	39
F5	59	−4	**D4**	0	4
A5	17	29	**D4**	1	1
D6	4	−20	**G4**	−272	114
A5	15	−23	**A4**	−309	264
F5	57	31	**B4**	−400	189
D5	10	−7	**A4**	−309	139
F5	47	28	**G4**	−334	199
A5	−16	−43			
E5	9	9			
C#5	2	−8			
A	0	−1			
E4	11	60			
C#4	32	14			
A3	41	12			

Student 6			Student 7			Student 8			Student 9		
Pitches	**Before**	**After**	**Pitches**	**Before**	**After**	**Pitches**	**Before**	**After**	**Pitches**	**Before**	**After**
D4	15	15	**D4**	15	15	**D4**	−13	−2	**A4**	10	9
E4	23	−13	**E4**	10	7	**F#4**	−68	−20	**B4**	72	7
F#4	11	12	**F#4**	−17	23	**E4**	−25	23	**C#5**	45	−4
G4	0	−2	**G4**	−15	−6	**D4**	−14	0	**D5**	141	23
A4	−6	−6	**A4**	10	8	**E4**	−22	10	**E5**	80	42
B4	31	−89	**B4**	−16	2	**F#4**	−23	17	**E5**	−76	44
C#5	−27	−50	**C#5**	−7	60	**G4**			**E5**	−76	44
D5	−16	6	**D5**	4		**A4**	2	0	**E5**	−76	44
E5	10	−8	**E5**	−32	−5	**B4**	17	25	**F#5**		
F#5	−26	35	**F#5**	−38	−8	**C#5**	−76	−6	**D5**	−11	−22
G5	109	25	**G5**	−55		**D5**	10	17	**A5**	−78	−36
A5	83	−60	**A5**	17	0	**E5**	−17	−23	**F#5**		−20
B5	1	45	**B5**	24	7	**F#5**	−20	−29	**E5**		−12
C#6	−37	32	**C#6**	39	22	**G5**	69	71	**F#5**		−41
D6	141	−59	**D6**	48	44	**A5**	10	20	**D5**		0
C#6	204	163	**C#6**	32	26	**B5**	−20	−15	**A5**		−48
B5	117	102	**B5**	8	6	**C#6**	−15	−78	**F#5**		−30
A5	−89	−96	**A5**	29	−13	**D6**	−14	−31	**E5**		−6

Student 6			Student 7			Student 8			Student 9		
Pitches	**Before**	**After**	**Pitches**	**Before**	**After**	**Pitches**	**Before**	**After**	**Pitches**	**Before**	**After**
G5	–25	54	**G5**	37	9	**C#6**	–31	–90	**E5**		–6
F#5	–20		**F#5**	–8	19	**B5**	–40	–29	**D5**		–35
E5	12	19	**E5**	5		**A5**	11	15	**D5**		–22
D5	23	72	**D5**	–44	3	**G5**	–38	–7	**D5**		–34
C#5	10	–39	**C#5**	–2	3	**F#5**	–52	–10	**D5**		–34
B4	–24		**B4**	3	8	**E5**	–58	–63	**C#5**		–13
A4	–1	–12	**A4**	6		**D5**	–67	–59	**C#5**		–15
G4	7	30	**G4**	1		**C#5**	–71	–68	**C#5**		–11
F#4	–26	–38	**F#4**	–19		**B4**	12	–30	**C#5**		–16
E4	–17	2	**E4**	–23		**A4**	–74	–33	**B4**		4
D4	15	15	**D4**	–2		**G4**	–44	–41	**B4**		3
						F#4	–75	43	**B4**		4
						E4	–11	–39	**A4**		10
						D4	–12	–10	**C#5**		–41
									E5		–6
									E5		–6
									D5		–34
									D5		–31
									D5		–29
									D5		–29
									C#5		–3
									C#5		–13
									C#5		–5
									C#5		–5
									B4		–24
									B4		–30
									B4		–24
									A4		4

6. STUDENT INTEREST, PHYSICAL, PSYCHOLOGICAL AND SELF-ACTUALISATION OBSERVATION TABLE

Student No.	Willingness to create personally relevant mental Imagery	Independent use of mental training	Punctuality to lessons	Willingness to arrange extra lessons	Willingness to participate in group activities	Eagerness to perform in front of others	Positive attitude towards challenges	Regular Practice Habits	Overall Enthusiasm

7. IMAGERY AND VIOLIN TECHNIQUES EMPLOYED BY EACH STUDENT FOR EXERCISE 11

Student	Imagery	Techniques	Student	Imagery	Techniques
1	Cat	Legato, longer bows	2	Happy	Smooth, even bow strokes (*detaché*), bowing midway between bridge and fingerboard
	Dog	Short loud bow strokes (*martelé*), bowing midway between bridge and fingerboard, *forte*		Neutral	Bowing towards fingerboard (*sul tasto*), *piano*
	Happy	Stable sound, bowing midway between bridge and fingerboard		Angry	Short, loud *martelé* bow strokes, middle of bow
	Hare	Heavy, slow, short *spiccato* bow strokes, middle of bow		Sleepy	Slow tempo, bowing over fingerboard *(sul tasto)*
	Heart	Smooth bow changes, slurred notes		Shock	Short strokes, all up-bows
3	Sleepy	Slow tempo, bowing over the fingerboard (*sul tasto*), *piano*	4	Emoji with sunglasses	Bowing on the bridge *(sul ponticello)*
	Shock	Bowing over the bridge (*sul ponticello*)		Happy	Musical work transposed a 5th down
	Scared	Tremolo, *sul ponticello*		Angry	Short, loud *martelé* strokes, middle of bow
	Happy	Stable, focussed sound		Sad	Slow tempo, played near the point of bow, *piano*
	Sad	Played a 5th down, slower		Asleep	Bowing over fingerboard *(sul tasto)*
5	Light	Tremolo bowing, towards the bridge	6	Thinking	Slow bows, towards the fingerboard
	Scared	Slow, short bow strokes, slow tempo		Tongue out	Upwards glissandi
	Dark	Notes played on lower strings		Emoji with dollar signs in eyes	Stable sound, bowing midpoint between bridge and fingerboard
	Cold	Tremolo on the bridge (*sul ponticello*)		Pizza	Pizzicato
	Hot	Heavy bow strokes *(detaché)*		Ice Cream	Stable, smooth sound, bowing midpoint between bridge and fingerboard

Student	Imagery	Techniques	Student	Imagery	Techniques
7	Thinking with glasses	Accurate bow distribution and intonation	**8**	Ghost	Fast, floating bow, over fingerboard *(sul tasto)*
	Long nose	Irregular pulse		Skull	Playing above string with the bow
	Night time	Smooth sound, all notes in slurs		Pixelated Minecraft Character	Short, heavy bow strokes (*martelé*)
	Sleepy	Medium fast bow strokes *(sul tasto)*		Neutral Emotion	Gentle sound over the fingerboard *(sul tasto)*
	Fire	Fast, long, bow strokes, towards the fingerboard		Emoji with hearts in eyes	Glissandi upwards between each note
9	Surprise	Tremolo			
	Angry	Short bow strokes, all downbows			
	Crying	Glissandi downwards after each note			
	Emoji with sun hat	Slow vibrato with left hand			
	Dog	Fast, long bow strokes			

Mental Training in the Improvement of Violin Playing Skill in the Primary School Pedagogical Process

Whilst aspects of mental training have been used by professional musicians to assist in practice, memorisation, concert preparation and in the reduction of performance anxiety (Connoly, Williamon, 2004), they are rarely used systematically in pedagogical processes.

Integrating insights from neuroscience, this study adapts mental training for use in primary school violin teaching and learning. It addresses pedagogical approach and develops a system of 15 exercises to assist in developing students' violin-playing skills in a way that carries personal meaning, encourages creative experimentation and promotes inventive musical thought.

Definitions

Mental Training has been defined as the training of the mental practice - performing an action in the mind without its physical realisation (Eberspächer, 2007). In music, mental training aims to develop the imagination of both movement and sound (Klöppel, 2010).

It is based on the manipulation of *mental imagery* (Budnik-Przybylska et al., 2023) that can be:
1) *Direct* - "seeing" in the mind's eye - employing any single or combination of sense modes (visual, haptic/motoric, auditory, etc, (see Thomas, 2016)
2) *Indirect* - metaphoric imagery conveying an (abstract) object or idea that provides sensory-motor concepts relating to an action/skill (e.g. Stergiou et al, 2019; Pecher et al, 2011; Short et al., 2001), or concepts of subjects and knowledge (e.g. DeSantis et al., 2022; Saban, 2008).
Mental training can also reference emotional (Immonen et al., 2012) and observational aspects (Mayer, Hermann, 2011) and combine physical movement with mental imagery (McHugh-Grifa, 2011).

The Process of Mental Training

Mental training often involves the alternation of mental and physical aspects: e.g. **mental practice** - *feedforward* (imaginative projection of movement and sound) followed by **physical practice** - *feedback* (auditory perception and analysis of the actual sound produced) (See fig.1).
This cyclic process bears similarities to the instrument-playing procedures identified in neuroscience (see Zatorre et al., 2007; Wan, Schlaug, 2010; Keller, 2012; Gruhn, 2015) and helps to bring these processes into conscious awareness.

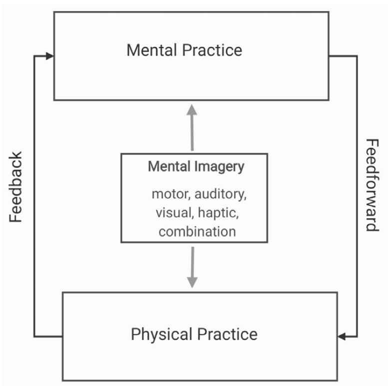


Figure 1. The process of mental training with already-trained practitioners

Learning in the Brain and Mental Training

Neuroplasticity - "the property of the brain that enables it to change its own structure and functioning in response to activity and mental experience" (Doidge 2015, 14), which allows the reshaping and reorganisation of the network of dendrite-neuron connections (Hawkins, 2021), is central to learning in the brain. Memory retrieval and executing an action occurs more efficiently and accurately the more synaptic connections there are between neurons, which strengthen and increase in number during learning and repeated learning (Willis, 2006).
Significantly, both mental and physical practice activate many of the same brain areas (see Decety 1996; Hanakawa, 2016; Zatorre, Halpern, 2005) and training with imagery of motor movements has been shown to achieve use-dependent plasticity in the brain, similar to that noted after physical movement (Ruffino et al., 2019). Thus, mental training assists in developing and strengthening neural connections that are essential in learning.

This study argues that metaphoric imagery can also assist in broadening the network of activated neurons to varied regions of the brain - which has been shown to help learning become longer-lasting (Amaral, 2021) - and can assist students to interact with the subject content. This, in turn, can contribute to attentional processes, noted as being important in learning (e.g. Robinson, 2012).

Pedagogical Aspects and the Organisation of a System

The pedagogical aspects of mental training in this study are based on humanistic theories of individual approach (including Rogers 1961; Bruner, 1964; Barker, Shaik, 2011), and experiential learning theory (see Kolb 1984; 2012; 2018) and discusses the occurrence of spontaneous and deliberate mental imagery (see McCrum, 2016; Kosslyn, 1995; Pearson et al., 2015) in relation to pedagogical approach and stress reduction in learning.

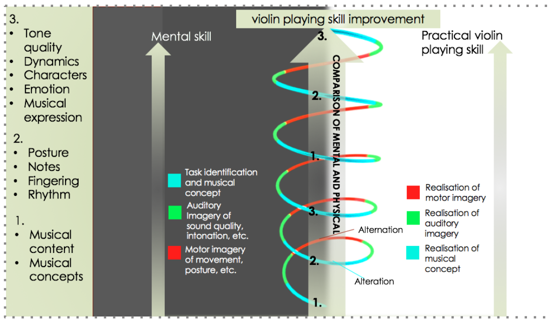


Figure 2. Violin playing skill improvement model

Based on the combined literature from pedagogy, neuroscience, psychology and music pedagogy, a violin skill improvement model was developed (see figure 2). Designed as a spiral travelling through the mental and physical processes involved when learning and improving the skill of violin playing, each turn represents the student's skill transforming and evolving, building on the experience gained from the previous turn. The spiral concept also helps to organise the sequence of learning, and shows how this sequence repeats. At each repetition, the skill of violin playing improves, becoming more musically and emotionally meaningful to the student.

The system of mental training and the 15 exercises were developed based on the combined literature and the skill improvement model, incorporating elements of creativity, personal significance, and multimodal learning

References

1. Amaral, J. A. A., Fregni, F. (2021). Applying Neuroscience Concepts to Enhance Learning in an Online Project-Based Learning Centred Course. *Journal of Problem Based Learning in Higher Education*, Volume 9 No.2. Doi: https://doi.org/10.5278/ojs.jpblhe.v9i2.5892
2. Barker, P. Schaik, P. v. (2011). Mental Models and Lifelong Learning. In: N. M. Seel (Ed.) *Encyclopedia of the Sciences of Learning.* New York: Springer
3. Bruner, J. S. (1961). The act of discovery. *Harvard Educational Review*, 31, 21-32.
4. Budnik-Przybylska, D., Syty, P., Kaźmierczak, M. *et al.* (2023). Exploring the influence of personal factors on physiological responses to mental imagery in sport. *Sci Rep* **13**, 2628 (2023). Connolly, C. , Williamon, A. (2004). Mental Skills Training. In: Williamon, A. (Ed.) *Musical Excellence: Strategies and Techniques to Enhance Performance*. Oxford: Oxford University Press
5. Decety, J. (1996). Do executed and imagined movements share the same central structures? *Cognitive Brain Research*, Volume 3, p. 87-93.
6. DeSantis, B., Deck, S., Hall, C., Roland, S. (2022). Why do singers use imagery? *Research Studies in Music Education 2022, Volume 44(3), 527-540.* Doi: 10.1177/1321103X221081984
7. Doidge, N. (2015). *The Brain's Way of Healing*. New York: Penguin Group.
8. Eberspächer, H., (2007). *Mentales Training*. Grünwald: Corpress. Sportinform.
9. Gruhn, W. (2015). How the brain plays the music A neurobiological perspective on music performance and learning. *Meakultura,* Number 257. Retrieved: http://www.meakultura.pl/publikacje/how-the-brain-plays-the-music-a-neurobiological-perspective-on-music-performance-and-learning-1349
10. Hanakawa, T. (2016). Organizing motor imageries, *Neuroscience Research*. 104: 56-63. doi: 10.1016/j.neures.2015.11.003
11. Hawkins, J. A. (2021). *Brain Plasticity and Learning: Implications for Educational Practice.* Cham: Palgrave Macmillan/Springer
12. Immonen, O., Ruokonen, I., Ruismäki, H. (2012). Elements of Mental Training in Music. *Procedia - Social and Bhavioral Sciences* 45 (2012) 588-594.
13. Keller, P. E. (2012). Mental imagery in music performance: underlying mechanisms and potential benefits. *Ann. N.Y. Acad. Sci.* 1252 (2012) 206–213.
14. Klöppel, R. (2010). *Mentales Training für Musiker*. Kassel: Gustav Bosse Verlag GmbH.
15. Kolb, D.A. (1984). *Experiential learning. Experience as the source of learning and development*. New Jersey: Prentice Hall.
16. Kolb A. Y., Kolb, D. A. (2012). Experiential Learning Theory. In: N. M. Seel (Ed.) *Encyclopedia of the Sciences of Learning.* New York: Springer.
17. Kolb, A., & Kolb, D. (2018). Eight important things to know about the experiential learning cycle. *Australian Educational Leader*, *40*(3), 8–14. https://search.informit.org/doi/10.3316/informit.192540196827567
18. Kosslyn, S., Behrmann, M., Jeannerod, M. (1995). The Cognitive Neuroscience of Mental Imagery. N*europsychologia*, Vol. 33, No. 11, p. 1355-1344.
19. Mayer, J., Hermann, HD. (2011). *Mentales Training*. Berlin: Springer.
20. McCrum, R. (2016). 'Perfect mind': On Shakespeare and the brain. *Brain*, 139(12), 3310-3313. Doi: https://doi.org/10.1093/brain/aww279
21. McHugh-Grifa, A. 2011. A comparative investigation of mental practice strategies used by collegiate-level cello students. *Contributions to Music Education* 38(1): 65-79. http://www.jstor.org/stable/24127177
22. Pearson, J. (2019). The human imagination: the cognitive neuroscience of visual mental imagery. *Nat Rev Neurosci 20, 624–634 (2019).* https://doi.org/10.1038/s41583-019-0202-9
23. Pecher, D., Boot, I., & Van Dantzig, S. (2011). Abstract concepts: Sensory-motor grounding, metaphors, and beyond. In B. Ross (Ed.). *The Psychology of Learning and Motivation*, vol. 54, pp. 217-248. Burlington: Academic Press.
24. Robinson, P. (2012). Abilities to Learn: Cognitive Abilities. In: Seel, N. M. (Ed.) *Encyclopedia of the Sciences of Learning.* New York: Springer.
25. Rogers, C. (1961). *On Becoming a Person*. Boston: Houghton Mifflin.
26. Ruffino, C., Gaveau, J., Papaxanthis, C. (2019). An acute session of motor imagery training induces use-dependent plasticity. *Scientific Reports* 9, 20002 (2019). doi: 10.1038/s41598-019-56628-z
27. Saban, A. (2008). Primary School Teachers' and Their Students' Mental Images About the Concept of Knowledge. *Elementary Education Online, 7(2), 421-455, 2008*
28. Short, S. E., Affremow, J., Overby, L. (2001). Using Mental Imagery to Enhance Children's Motor Performance. *Journal of Physical Education, Recreation & Dance*. 72:2, p. 19-23.
29. Stergiou, M., Raheb, K., Ioannidis, Y. (2019). Imagery and metaphors: from movement practices to digital and immersive environments. In: *Proceedings of the 6th International Conference on Movement*

and Computing (MOCO '19). Association for Computing Machinery, New York, NY, USA, Article 18, 1–8. https://doi.org/10.1145/3347122.3347141

30. Thomas, Nigel J. T. (2016). Mental Imagery. In E. N. Zalta (Ed.), *The Stanford Encyclopedia of Philosophy* (Summer 2016 ed.). Retrieved from <http://plato.stanford.edu/archives/sum2016/entries/mentalimagery/> .
31. Wan, C. Y., Schlaug, G. (2010). Music Making as a Tool for Promoting Brain Plasticity across the Life Span. Neuroscientist, 2010 Oct; 16(5):566-577.
32. Willis, J. (2006). Research-Based Strategies to Ignite Student Learning. Insights from a Neurologist and Classroom Teacher. USA: Alexandria, ASCD
33. Zatorre, R. J., Chen, J. L, Penhune, V. B. (2007). When the brain plays music: auditory–motor interactions in music perception and production. Nature Reviews, Neuroscience, volume 8, July 2007, p. 547-558.
34. Zatorre, R. J., Halpern, A. R. (2005). Mental Concerts: Musical Imagery and Auditory Cortex. Neuron, Vol. 47, 9–12, July 7, 2005

A System of Mental Training Exercises

Approach and Introduction to the Exercises

The system of mental training includes the consideration of approach and lesson structure (see chapter 1.3, page 78). This includes:

1) A verbal warm-up, together with recollection of achievements in the previous lesson, planning of lesson content, identification of focal areas and goal setting.
2) Initial student playing, during which the teacher assesses the playing non-verbally, considers the use of positive language for discussion with the student and after the playing encourages constructive age and stage relevant student self-assessment.
3) Separation of tasks into their separate components (see fig.1 below and chapter 2.3) according to the hierarchy of musical-technical components which also correspond to the sequence of learning set out in the skill improvement model.

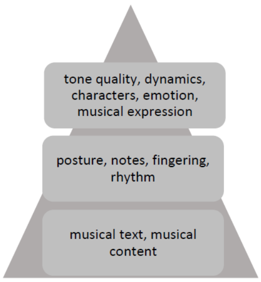


Figure. 1. The hierarchy of musical-technical skills viewed in the lesson situation

The hierarchy can be drawn together with the student and be followed from bottom to top. (It can also serve as a practice plan or checklist for later student independent practice.)

The hierarchy can now assist in choosing a mental training exercise (see "stages" in fig. 4), which can be chosen according to the needs and mood of the student.

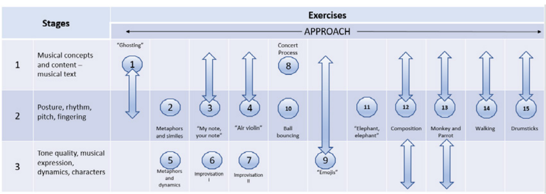


Figure 2. Organisation of exercises into three stages: a system of mental training

Mental Training Exercises

Exercise 1 "Ghosting": *For the development of feedforward of sound, intonation and tone production.*

Two to four bars from a musical work are chosen and the following steps are carried out:

1) The student plays the excerpt of music (the teacher listens, without commentary – in accordance with the theory on the pedagogue reducing verbal instructions);
2) The teacher asks the student to put the bow down on the table and hold the violin only in playing position.
3) The teacher asks the student to pay attention to posture, for which imagery can be used (see Exercise 2 below), to make sure that the left hand is being held correctly.
4) The student then puts the bow down and reads the music with the violin being held only.
5) The teacher then plays the excerpt whilst the student follows the music and fingers the excerpt – that is, the student places her fingers on the violin and follows the music as if she was playing the music herself, but the sound is being produced by the teacher's playing (see fig. 3).
6) The teacher observes whether the student has understood which fingers and positions need to be used, and whether the excerpt needs to be repeated. If yes, then step five can be repeated.
7) The student then puts down the violin and takes only the bow.
8) The teacher then plays the excerpt again and the student reads the music and mimes with the bowing required in that excerpt (see fig. 3).
9) The student plays the excerpt alone.
10) The teacher suggests playing in a certain character – perhaps in the character of a large person, or in the character of a large animal. The students are encouraged to create their own imagery.
11) The student plays again whilst keeping this imagery in mind.

Figure. 3. Steps 5 and 8 of exercise 1

Exercise 2: *Metaphors and Similes. Developing concepts of posture through imagery of abstract, but familiar concepts personally relevant to the student.*

Imagery is developed together with the student. Examples are given here, but are not prescriptive.

Bow hold:

The frog of the bow could be compared to a television/computer screen, with the two right-hand fingers that cover it, "needing" to be there, because you cannot watch the television and play the violin at the same time!

Scenarios for the placement of the fingers on the bow and thumb underneath could include the imagery of a fish swimming up towards the top of a pond (for the thumb), with two friends – the middle two fingers, held in front of the frog representing two friends sitting on a bench by the pond, watching the fish in the pond swimming. Another friend – the index finger – decides to walk away a little, whilst a little bird is sitting on a nearby branch – the little finger placed on top of the bow – listening to the two friends nattering on the bench.

Whole body posture: The whole body posture could be described as being inside a clock, where the left arm points to 10 o'clock and the nose of the player points to 11 or 12 o'clock. In the gap between the left hand and the violin, a little bird could be imagined, or a rabbit in a rabbit-warren, who is listening to the violin.

Exercise 3: "My Note, Your Note"*: For rhythmic awareness. Also assists with musical concept and intonation.*

In this exercise, a musical phrase is chosen – four to sixteen bars, depending on the difficulty of the repertoire for the student, or indeed, the particular mood of the student on that day.

1) The phrase is divided between teacher and student: the student plays one note, the teacher plays the next.
2) The process is reversed, so that the teacher starts with the first note and the student plays the next (see fig. 42).
3) The student plays the whole excerpt.
4) The excerpt is then split up into bars: e.g., the teacher plays the first bar, the student plays the next.
5) This process is then reversed.
6) The student then plays the whole excerpt again.

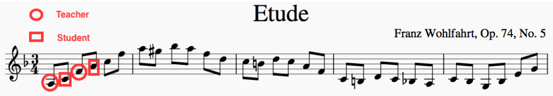


Figure 4. Alternation of teacher and student playing in Exercise 3

Exercise 4. "Air violin": ***For developing the independent awareness of the inner ear and intonation.***

In this exercise, the violin is not physically held at all.

The student reads the music and plays the correct fingers against the thumb whilst singing the pitches of the music. This exercise is created with the idea of creating an awareness of the deliberate process of exteriorisation, developing a sense of mental rehearsal without the instrument. It also connects to the research that supports combining movement with mental rehearsal, which is more effective than mental rehearsal alone.

Figure 5. Example of the movement of the fingers and thumb

Exercise 5. "Dynamics": ***For creating dynamic contrasts and characters. Also assists with memorisation and musical interpretation.***

This exercise utilises indirect mental imagery: the use of metaphors.

1) The teacher discusses the concepts of dynamics, phrasing and characters in the music and gives examples of contrasts, both with imagery and with playing the violin.
2) The student is asked to create their own imagery to represent the characters heard.
3) The student is asked what characters they see as *piano* and *forte.*
4) The student is asked to think of those characters whilst creating piano and forte dynamics on the violin.
5) The student is encouraged to create their own scenarios connected to those characters.

Exercise 6. Improvisation 1: ***For awareness of polyphony and for confidence-building.***

This exercise was devised around a simple exercise on the A string (see fig. 44), but can be used together with other exercises, such as those by H. Schradieck.

1) The student plays the exercise repeatedly and the teacher improvises.
2) The teacher plays the exercise, and the student improvises.

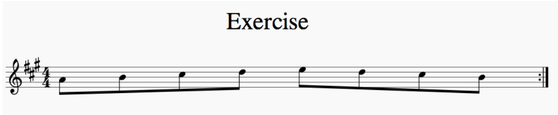


Figure 6. A simple exercise on the A string

This exercise is designed to build student confidence and encourage experimentation. Students are assured that every action is correct, eliminating the possibility of mistakes. It also creates an interesting way to play a very basic – and perhaps usually also uninteresting – exercise that is necessary in the early stages of learning. It can also serve as a warm-up following the initial verbal warm-up in the lesson.

Exercise 7. Improvisation 2: ***For developing awareness of musical characters, musical interpretation and different violin techniques.***

For this exercise a page from a comic, nature book or any picture is observed. Steps 4, 5 and 6 can be used interchangeably, depending on the time constraints of the lesson or the mood of the student.

1. Teacher and student discuss the different elements of the picture – perhaps there are different animals, or an interesting landscape with hills or forests, for example and/or weather aspects – such as wind or rain.
2. The teacher asks the student to take their instrument to try and give a certain element in the picture a sound. The teacher may ask, "How would you create the feeling of rain?" or "What kinds of sounds could illustrate the animal in the picture?"
3. The student experiments with different effects. The teacher can help if the student asks, or be reminded of the different techniques they may already know, such as pizzicato, *sul ponticello,* glissandi, flautando, etc. The student is encouraged to develop different sounds for the different elements in the picture. (The student may "invent" tremolo or a combination of tremolo and glissando.) The student is encouraged by the teacher if there is some shyness – because everything they do is good: it's their improvisation; all "mistakes" are allowed.
4. Without revealing to the teacher, the student chooses a character in the picture and plays it to the teacher. The teacher needs to guess the character that is being portrayed. The teacher and pupil improvise at the same time, as if playing a duet. The teacher may introduce some different effects on the instrument.
5. The student can play alone – incorporating all the elements one after the other in the picture.

Exercise 8: Rehearsing the concert process: ***For developing concepts of mental rehearsal. Also helps with memorisation, building confidence leading up to performance and assists in attention to the learning material.***

Developing imagery of the concert process – combination of action and imagery:

1. **Student and teacher exit the classroom and close the door.** Imagery of the time before entering the stage is developed: The teacher describes the situation that can occur before playing, and before entering the stage, including how to safely hold the violin in resting position (preferably under the right arm, so that one arm is free to hold on to any bannisters or open or close doors, etc).
2. **The teacher describes an imaginary scene of the stage and the circumstances that might precede the student's performance.** For instance, the student may need to wait for the previous performance to end before playing, so the teacher can ask the student to listen to ascertain whether there is anyone still playing.
3. **Teacher and student enter the classroom as if entering the stage**. The teacher asks the student to imagine the audience who are now clapping (the teacher may also clap to imitate the audience). In order to remind the student to bow, the teacher can ask, "What do we have to do when the audience is clapping?"
4. **The student prepares to play**. Still imagining the direction of the imaginary audience, the student can be prompted to stand so that the f-holes of the violin are facing the audience and in a location in which the student can still communicate with the accompanist.
5. **The student plays the work(s) in the same order as will be required in the concert/exam.** If there are several works to be played, the student and teacher discuss what will happen in the gaps between the pieces: where the violin will rest and whether or not to bow to the audience, etc.
6. **The musical work(s) are played**. On completion, the student is asked what needs to be done on stage after playing. The student can be reminded to smile (or imagine smiling), to bow before exiting the imaginary stage, imagining the applause from the audience. Teacher and pupil again exit the classroom, imagining that they are exiting the stage.
7. **Analysis of aspects of this process.** Using positive language and after congratulating the student for completing the process, the teacher asks how the student feels and whether they feel that they have achieved what was planned; whether anything went better or worse than expected, or if anything took them by surprise, for instance.
8. **This whole exercise can be repeated until the student becomes comfortable with imaging the concert situation.** It is envisaged that the exercise will become a reference point for later mental rehearsal. The exercise can be repeated in subsequent lessons if necessary. (In a lesson plan this could be at the end of the lesson to recap on the day's work or near the beginning of the lesson to assist in captivating attention or adapting to the lesson environment)

Exercise 9: "Emojis": ***For developing musical characters and awareness of musical interpretation, assists with creating interest in repetition and practice and concepts of feedforward.***

1. The student plays through a musical work, or a section of it.
2. The student draws five different "emojis" or faces showing emotions on sticky note paper.
3. The student arranges the pictures in an order on the music stand, not showing the teacher the order of the emotions.
4. The student plays again and the teacher guesses which emotion they are trying to portray.
5. Step four is repeated 5 times (or for as many times as there are emojis).
6. Teacher and pupil discuss the different musical effects explored and the different techniques employed to create them.

Exercise 10: Bouncing ball and left hand pizzicato. ***For developing feedforward processes during a current action.***

To be carried out without the bow and and is split into three levels.

Level 1, preparation:

1) Whilst holding the violin on the left shoulder and with the left hand in playing position, the student bounces a soft ball and catches it.
2) After successfully catching the ball, the teacher asks the student to play left-hand pizzicato on a specific string with a specific finger. (The teacher will vary the string and finger each time this step is repeated)
3) The student plays the left-hand pizzicato and bounces the ball again, after which stage 2 is repeated.

Level 2, personal goal setting:

1) Before bouncing the ball, the teacher asks the student to choose the string and finger for playing the left hand pizzicato.
2) Still with the violin on the left shoulder and left hand in playing position, the student bounces the ball with the right hand and catches it.
3) The student realises the goal of playing the left hand pizzicato.

Level 3, increased challenge:

1) The student is now asked to choose two strings and two fingers before bouncing and catching the ball (these can be played as double-stops or consecutively)
2) The student realises the goal set.
3) Repeat these steps until the student can set goals and achieve them with ease.

The challenge could be increased to four fingers and strings and could be used to develop the "Geminiani grip" in more advanced students.

Exercise 11: "Elephant, Elephant": ***For developing concepts of tone production, experimentation and self-awareness of bow weight and speed.***

The purpose of this exercise is to assist in the development of awareness of skill - particularly bow speed and arm weight - but also to introduce the concept of repetition and experimentation; to be able to work upon something and improve it with each repetition. This exercise uses imagery to label the bow with three (imaginary) areas and assists in developing awareness of bow speed (see figure 6).

Figure 6. The violin bow split into three areas

1) Building the imagery. Because the bow is travelling, the teacher asks the student to imagine that a train (or car) is travelling from their hometown (e.g. "Cēsis") and shows the area of the bow by the frog (heel).
2) The student is asked to imagine where the train could travel to by the time the train reaches the tip of the bow (e.g. "Rīga")
3) The student is then asked which town is halfway between Cēsis and Rīga? (e.g. Sigulda).
4) The student is asked how many elephants are on the train from Cēsis to Rīga.
5) The student plays an open string on a "down bow" - a sound starting in Cēsis (by the heel of the bow) and travels with the bow (train) towards Rīga, whilst the teacher counts (aloud), "Elephant, Elephant, Elephant." One elephant is equal to one beat at 80 BPM. (The teacher observes the metronome, which is in silent mode, in order to count the beats accurately.) The imagery of an elephant is employed to give the idea of the feeling of weight in the hand and arm as the bow travels.
6) The teacher and pupil compare/discuss the number of elephants that have been counted.
7) The student now plays an "up bow" from Rīga to Cēsis (from the tip of the bow to the heel of the bow), whilst the teacher and pupil again count the number of "Elephants".
8) The number of elephants are compared from both directions.
9) The student is asked to now travel from Cēsis to Sigulda (starting on a down bow) and from Sigulda to Riga, etc.
10) Analysis of results and repetition of exercise.

The number of elephants or beats can be notated in a table, for easier analysis (see fig.7 below). The numerical values given in figure 7. are examples only.

Bow Distributions	No. of Elephants / Beats (□ = 80)	
	1st time	2nd time
Cesis - Riga (down-bow)	e.g. 8	
Riga - Cesis (up-bow)	12	
Cesis - Sigulda (down-bow from heel to middle of bow)	3	
Sigulda - Riga (down-bow from middle of bow to tip)	5	
Riga - Sigulda (up-bow from tip to middle)	6	
Sigulda - Cesis (up-bow from middle to heel)	4	

Figure 7. Bow distribution table for exercise 11

Exercise 12: Melodic composition: ***For general development of awareness of notation, its associated sound and the feedforward processes of violin playing.***

For this exercise, a die, altered to display the note names of the musical scale (see fig. 8), a white-board with musical leger lines and a white-board marker is required. The student "builds" their own musical environment and is encouraged to begin to pre-hear pitches and imagine how to achieve them physically on the violin.

Figure 8. A die, altered to display note names

1. A treble clef is drawn on the whiteboard and a time signature is chosen (e.g. 3/4 or 4/4).
2. The student throws the dice to create one to two bars of music (4 or 8 notes in 4/4) and writes each note as a crotchet.
3. Whilst writing the individual notes, the student is encouraged to sing the note name at the correct pitch (the teacher helps in this process) and imagine with which finger the note on the violin is produced.
4. After writing the notes, the student takes the violin and plays the pitches notated on the white board.
5. The white board can be turned upside down.
6. The student attempts to imagine how to play the newly transformed notes and their associated sound before playing them on their instrument, either against their finger and thumb, as in exercise 4, or on their instrument without the bow, as in exercise 1.

Exercise 13: "Monkey and Parrot" / Improvisation and improvisation. ***For developing creative, feedforward processes and introduce new technical and musical concepts. Also useful as a warm-up in lessons to activate thinking and listening processes.***

1) The student is offered to pretend they are either a monkey or a parrot. (The teacher remembers that the monkey improvises and the parrot imitates)
2) The teacher (or student) improvises - approximately 8 notes, depending on the student skill level. (If the teacher improvises, then the teacher can include technical elements the teacher considers would be interesting for the student, or that will help the student develop a better technique)
3) The student (or teacher) imitates.
4) If the student's imitation is not accurate, the teacher asks if the student would like to hear the improvisation again, so they can try a second time, but no criticism is given.
5) The teacher and student change roles.
6) When the teacher imitates the student's playing, it needs to be played with a good sound and as artistically as possible.

Exercise 14: "Walking Pulse": ***For developing a feeling of internally-generated pulse. Also helps with memorisation.***

Whilst the main purpose of this exercise is to develop an internally driven sense of pulse, it also serves to consolidate the text of the musical extract and encourages the student to work from memory.

1. The student plays through an except (4 to 8 bars) of a musical work.
2. The student decides (together with the teacher) on the required speed of the excerpt (according to the needs of the student).
3. Without the violin, the student walks at this tempo, so that each footstep represents a crotchet (or quaver, or sub-division, depending on the speed and time signature of the musical work), whilst imagining the pitches and sounds of the musical excerpt.
4. The student takes the violin and plays the violin whilst walking at the desired pulse and at the same speed as imagined in step 3.

Exercise 15: "Drumsticks": ***For developing internally-generated musical pulse and concepts of musical text. Can also assist in memorisation.***

For this exercise, two drumsticks are required. Designed for the purposeful development of the concept of pulse during and before the beginning of the music being played, this exercise also provides an opportunity for focused listening of a musical work, drawing attention to rhythmic nuances.

1. The student plays an excerpt of a musical work (4 to 8 bars, or more depending on the difficulty of the piece or learning stage of the student).
2. The student takes the drumsticks and is invited to "play the drums" or "be the metronome for the teacher." (The teacher demonstrates how to tap the drumsticks together to make a sound.)
3. The student takes the drumsticks, tries them out, and decides on the pulse. (The teacher can assist by singing/humming the melody of the musical excerpt.)
4. The student beats a whole bar in before the teacher plays the musical excerpt on the violin. The student continues to tap the drumsticks to the pulse during the teacher's playing.
5. The student and the teacher swap roles: the teacher now taps the pulse with the drumsticks and the student plays.
6. The student plays the musical except again on the violin without the drumsticks being tapped.

9. INTERVIEW QUESTIONS FOR EXPERT STRING TEACHERS

Country: ______________________________ **Number of years experience teaching:** ____

1) Could you please describe your experience and expertise in teaching young violinists? How long have you been involved in music education?

2) In your opinion, what are the key cognitive processes (the process of acquiring knowledge and understanding through thought, experience, and the senses) involved in learning and playing the violin? How do you believe mental training can support or enhance these cognitive processes?

3) Are you familiar with the concept of mental training (or exercises that purposefully alternate mental and physical aspects) in the violin teaching and learning process? If yes, what are your thoughts on incorporating mental training exercises into the teaching and learning processes of young student violinists?

4) Do you already use exercises similar to the mental training exercises in this study in your teaching practice? If so, describe the exercises that you use.

5) Based on your experience, are there specific areas or techniques that young violinists often struggle with?

6) Do you believe that mental training exercises could address these challenges?

7) What are your thoughts on the design and use of the mental training exercises used in this study? Are there any aspects that you find noteworthy or would find useful in your practice?

8) How would you envisage integrating mental training exercises into the regular violin teaching and learning process? What recommendations or considerations would you suggest for incorporating these exercises?

Thank you for your answers!

10. INTERVIEW EXTRACTS AND CODES FOR QUESTION 2 OF EXPERT INTERVIEWS

Participants	Interview extract	Codes
1	You have to spatially be aware.	Spatial awareness
	You're trying to think ahead to the next part.	Multitasking
	Figuring out a way, like connecting left and right hand on the piano	Cognitive load management
	connecting spatial awareness with sight reading, or these different things where they meet	Integration of skills
2	Anticipation (what it is that the student wants to accomplish or hear).	Anticipation
	Imitation (of sound that is heard or imagined, and/or of physical movement).	Imitation
	repetition (of what is learned)	Repetition
	adaptation (what is learned to one's own physical body to his/her own musical interpretation)	Adaptation
3	One of the main cognitive processes that needs to be addressed is playing from memory.	Memory recall
	This is one of the main criteria in music school.	Memorisation
4	Little children are like this – that they feel everything straight away.	Individual childhood sensitivity
5	I haven't thought about it defining them scientifically, but I believe mental training can support cognitive processes.	Believes mental training helps cognitive processes
6	Yes, but intuitively. I heard about the theme/term only through you.	Intonation and rhythm
	And especially with the young ones, even in the nursery school.	Mental-physical connection
	If you can sing it (mentally or aloud), you can play it	Vocalisation
	Imagery is at the base of everything	Imagery
7	Connecting to children's previous experience, which is not that much considering they've only been alive for like five, six years, but I think that's quite key.	Connecting individual childhood experience
8	Understanding. The way of thinking about playing.	Thinking about playing
	Is it about pitch or just putting fingers down?	Pitch and finger placement

11. INTERVIEW EXTRACTS AND CODES FOR QUESTION 3 OF EXPERT INTERVIEWS

Participants	Interview extract	Codes
1	"Yeah, I think most of it is approached. Like there are a lot of books people have you read in college... So that's a pretty big part of the collegiate curriculum; it is part of the learning process. I don't know if anyone really, well I feel like it's rare that people take those books and say, okay here's how it applies to us. Sometimes I feel like there's a little bit of a gap between that. You just have to do your own assuming."	Gap in practical application in music pedagogy
2	"Yes, I am very familiar with it and I was taught about it by my teacher at the Manhattan School of Music and it changed the way I practised."	Positive impact and incorporation into practice
3	"Yes, time to time, I do something like that. It's important from the 2nd to 7th class."	Occasional use for young students
4	"Demonstration – yes. And if there is some new, a new fingering, etc."	Demonstration as a possible form of mental training
5	"Something of it, yes. Not exactly the same as you use. About metaphors – yes... I use metaphors for the bigger students too."	Use of metaphors and imagery in teaching, especially for young students
6	"Yes, but intuitively... Only later on do we talk about technical 'reasons' for doing things... In the younger classes, you can work only in this way."	Intuitive use, especially with young students
7	"I am now a little bit more... Yeah, your ideas are great. I might steal them!"	Increasing awareness and interest in incorporating
8	"Yes, but I work with the musical score, more than imitation."	Focus on using aspects together with musical scores and notation

12. INTERVIEW EXTRACTS AND CODES FOR QUESTION 4 OF EXPERT INTERVIEWS

Participants	Interview extract	Codes
1	"Yeah, I think most of it is approached. Like there are a lot of books people have you read in college... So that's a pretty big part of the collegiate curriculum; it is part of the learning process. I don't know if anyone really, well I feel like it's rare that people take those books and say, okay here's how it applies to us. Sometimes I feel like there's a little bit of a gap between that. You just have to do your own assuming."	Gap in practical application in music pedagogy
2	"Yes, I am very familiar with it and I was taught about it by my teacher at the Manhattan School of Music and it changed the way I practised."	Positive impact and incorporation into practice
3	"Yes, time to time, I do something like that. It's important from the 2 to 7th class."	Occasional use for young students
4	"Demonstration – yes. And if there is some new, a new fingering, etc."	Demonstration as a possible form of mental training
5	"Something of it, yes. Not exactly the same as you use. About metaphors – yes... I use metaphors for the bigger students too."	Use of metaphors and imagery in teaching, especially for young students
6	"Yes, but intuitively... Only later on do we talk about technical 'reasons' for doing things... In the younger classes, you can work only in this way."	Intuitive use, especially with young students
7	"I am now a little bit more... Yeah, your ideas are great. I might steal them!"	Increasing awareness and interest in incorporating
8	"Yes, but I work with the musical score, more than imitation."	Focus on using aspects together with musical scores and notation

13. INTERVIEW EXTRACTS AND CODES FOR QUESTION 5 OF EXPERT INTERVIEWS

Participants	Interview extract	Codes
1	"Merging technique with musicality... Learning notes quickly... Stage presence... Chamber music... forces us to keep going and think about our part more like a jazz musician..."	Merging technique with musicality, Learning notes quickly, Stage presence, Chamber music challenges
2	"Going from a slow bow and a fast vibrato... air, bowing and air, violin can really help... air, bowing and air, violin can really help... Well, I like your elephant idea. I was travelling from, say, this is to Cesis to Sigulda to Riga – that whole idea. I thought, okay, well, that's a great idea."	Coordination: fast vibrato and slow bow speed
3	"Coordination... Intonation... Inner hearing... They need to learn how to sing. But coordination is a major point."	Coordination, Intonation, Inner hearing and singing
4	"Intonation... playing with both hands together/coordination... Left hand problems... left wrist slips under the violin."	Intonation, Coordination, Tense hands, Left hand issues
5	"Rhythm, especially here in Latvia, syncopated rhythms... almost everyone has problems at the beginning of studies with ¾ rhythms... it's because of the bow; it's not natural."	Students' Individual challenges, Rhythm challenges, Syncopated rhythms, Bowing and note reading issues
6	"Connecting what's on the page to what you have to do on the violin... they read fingers more than notes... Posture and intonation... it's easier sometimes just to play by ear."	Reading music and finger coordination, Posture, Intonation, Playing by ear
7	"Bow holds, violin hold, bowing in parallel to the bridge, sound production... general stiffness."	Various technical challenges, Bow holds, Violin and bow positions, Sound production
8	"They are not reading the score... they play according to finger numbers... problems with intonation... parental involvement."	Note reading and fingering confusion, Intonation issues, Parental involvement

14. INTERVIEW EXTRACTS AND CODES FOR QUESTION 6 OF EXPERT INTERVIEWS

Participants	Interview extract	Codes
1	"Yes, I think that systematic approaches, someone creating those I think would be a really amazing addition to young pedagogy..."	Systematic approaches, High-level pedagogy, Resource availability
2	"So, you know, so many times we ask our students to try, try, try again, and sometimes I'll say stop, think about, maybe I need to start saying stop – let's do, put your violin down. Let's try it just through the air."	Addressing technical challenges, Use of mental practice, Visualisation
3	"Maybe not with laziness, but the other problems, yes, definitely... It can help with movement."	Movement improvement, Singing and listening exercises
4	"Yes, especially singing. Then the student understands what they can get from the music... Finger and thumb exercise – yes."	Singing and listening exercises, Finger and thumb exercises, Music appreciation
5	"I think the 'drumsticks' exercise would help with this. Also the exercise without the sound [Ghosting]... about giving good examples – and mirror neurons."	Exercises for technical improvement, Non-auditory bowing practice, Mirror neurons
6	"yes"	Affirmative response
7	"Yes, definitely. Yeah, in many ways. I guess with young children, everything to do with, oh, yes, imagery. So mental training, really."	Mental training and imagery for young children
8	"yes"	Affirmative response

15. INTERVIEW EXTRACTS AND CODES FOR QUESTION 7 OF EXPERT INTERVIEWS

Participants	Interview extract	Codes
1	"I thought they were super great. I thought they were exactly the kind of things needed... just expanding it out even further I think would be really cool."	Positive Evaluation and Expansion
2	"I plan to use all of them [the exercises]... I want my students to be able to play mindfully... always with intent, because I find that it's not music unless there's intent behind it."	Full Integration and Intent in Music
3	"Yes, especially "walking pulse", and "concert process."	Emphasis on Specific Exercises
4	"I like "My note, your note."... visualisation aspects are important in all musical works."	Preference for Specific Exercises
5	"Yes, when we were looking at the exercises, I thought: oh yes, I could take this and this – the images."	Selective Adaptation
6	"Yes, all of the exercises... if you don't use these types of exercises, you waste more time. You have to do them. It's quicker!"	Endorsement of All Exercises
7	"Yes, definitely. All of them, all 15 of them... I was just thinking because your dissertation is very scientific... I can understand them. Nicely laid out."	Comprehensive Support and Accessibility
8	"Yes, really many elements... It's more like an oral tradition. It's what we get from teachers."	Recognizing Informal Pedagogy

16. INTERVIEW EXTRACTS AND CODES FOR QUESTION 8 OF EXPERT INTERVIEWS

Participants	Interview extract	Codes
1	"it would be more engaging for the teacher and the student... if there was some exploring of these mental trainings.... If these things were incorporated a lot more I feel like we would be creating a whole artist in a better way."	Creating Engagement in Lessons
2	"the exercises are as much for you, the teacher, as it is for the student... You are making them be the explorers... it's exploring the violin more than exploring the music."	Mindfulness and Exploration
3	"I would like to see adaptations for even younger and older students."	Adaptation for Different Ages
4	"Improvisation with pictures... to imagine on what strings to play things for different characters."	Improvisation and Character Visualisation
5	"I think it's individual to the kid... you need to let the kid improvise and learn something new, perhaps without knowing it."	Individualised Approach
6	"I think the whole lesson should be mental training... calls for great creativity and really great time management."	Creativity and Interactive Learning
7	"the whole lesson can be quite a lot based on mental training... depends on the child."	Whole Lesson as Mental Training
8	"I would use and choose them individually – to help with certain aspects and have an option to use things quickly and change activities."	Personalised Integration