THE USE OF MENTAL TRAINING IN THE DEVELOPMENT OF RHYTHM AND INTONATION IN THE PRIMARY SCHOOL VIOLIN TEACHING AND LEARNING PROCESS

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Abstract
Mental training has been successfully employed by professional musicians and athletes, though rarely applied systematically in the instrumental teaching and learning process.
The aim of this study is to research the development of skill connected to rhythm and intonation in violin playing using mental training in the teaching and learning process of primary school violinists.
Six students (average age - 11) participated in two mental training routines. The first included alternation of physical practice and perception; the second, conducted away from the instrument, integrated movement of left-hand fingers, mental imagery, and perception of voice.
Analysis after the first mental training routine revealed rhythmic improvements (Z = 2.644, p = 0.008), whilst the second showed improvement in intonation (Z = -4.469, p = <0.001), suggesting that alternation of physical and mental aspects with perception assists in developing rhythmic skill, whereas intonational skill can be developed through combining perception, imagery and movement away from the instrument.
Key words: *mental training, mental imagery, violin pedagogy, rhythm, intonation, violin playing*

Introduction

Playing the violin and learning new repertoire requires development of precise sensory and cognitive processes that govern pitch and rhythm (Zatorre, 2007) as well as sensorimotor translation of the information read from a musical score (Stewart et al, 2003; Gruhn, 2015). This requires acquisition of a synthesis of mental and physical skill.

Research in neuroscience has highlighted the function of neuroplasticity in learning (Doidge, 2015), the creation and strengthening of connections between neurons that occurs similarly through physical or mental practice (Foerster et al, 2013; Ruffino et al, 2017), and, more recently, the important role of mental processes predictive of action, such as maintaining musical pulse (Patel & Iversen, 2014).

The process of mental training deliberately alternates physical and mental practice, and in doing so creates awareness of the mental and physical connections occurring in skill learning. Whilst this may help to explain its successful use by already-trained practitioners, the use of mental training with young learners, and the purposeful exploration of the aspects that could facilitate its later independent use, which is largely neglected in the literature, is this study's *raison d'être.*

This paper aims to research the development of skill connected to rhythm and intonation with young violinists using mental training and to test its effects pre- and post- mental training.

Object of the research: the teaching and learning process of primary school violinists.

Methods

Analysis of the literature concerning learning in the brain (Perry, 2006; McKenzie et al, 2014; Doidge, 2015), mental training in music and sport (Eberspächer, 2007; Klöppel 2010; McHugh-Grifa, 2011; Mayer & Hermann, 2011; Guillot et al, 2013), neuroplasticity in musicians (Brodsky, 2003; Haslinger et al., 2005; Rossi et al, 2019), similarities of brain activity in mental imagery and action (Ganis et al, 2004; Avanzino et al, 2015), spontaneous mental imagery production from vocabulary use (Kosslyn, 1990; McCrum, 2016) correlates of rhythm and intonation in the brain (Patel & Iversen, 2014; Tal et al, 2017), cognitive aspects of intonation (Zatorre, 2007; Gruhn, 2015), identification of mental training components in the violin literature (Galamian, 1962; Collins, 1962), analysis of intonation used in violin playing (Sassmanshaus, 2012; Keyes, 2013; Siljestam, 2013; Whitcomb, 2017).

Empirical analysis methods: Collection of student rhythm and intonation data: *Melodyne 4.* Statistical analysis: IBM SPSS Statistics 21.

Definitions

Mental training has been defined as the training of mental practice of action without its accompanying movement (Eberspächer, 2007) and used in sports psychology as a method of 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 use of mental imagery – 'seeing' in the mind's eye – which can be based on any sense mode (visual, haptic/motoric, auditory, etc.) or any combination of those (Thomas, 2014), the process mental training often consists of a phase of progressive relaxation, followed by mental imagery of movements and/or sounds, followed by its practical realisation on the instrument (see Klöppel, 2010).

Whilst the processes of movement and imagery are separate in many mental training texts, more recent studies in sport have found the advantage of combining movement with imagery – which reportedly enhances the production of mental imagery (Guillot et al, 2013). In music, the relatively unexplored area of miming instrument-playing movements – also called ‘air instruments’ – has also been acknowledged as being a form of mental practice (McHugh-Grifa, 2011). Thus, it is also possible to add to the definition of mental training the aspect of movement and/or perception. To understand this further and to understand how this can assist in placing mental training into a pedagogical environment, it is necessary to review the connections between learning and mental training in the brain.

Skill Learning and Mental Training

There is now a wide range of research in neuroscience concerning mental imagery and its application in mental practice; that it utilises similar areas in the brain to actual practice. This is confirmed in motor imagery, which uses the same motor areas in the brain as in actual movement (Avanzino et al, 2015); that visual mental imagery activates similar brain areas to actual visual perception (Ganis et al, 2004); and that the more activations occur – which includes both the mental and physical activity – the stronger the neuronal connections become for those actions, and more they are myelinated (McKenzie et al, 2014), allowing faster transmission of electrical signals and increased ease of execution. This neuroplasticity has been identified as being at the basis of learning in the brain, the results of which can be identified in professional musicians. These include cross-modal activations; that a stimulus – such as silent observation – activates auditory areas of the brain associated with producing those observed movements (Haslinger et al, 2005) and that musical score reading induces auditory imagery (Brodsky, 2003). Interestingly, adding mental imagery during stimuli – such musical score reading, or listening during score reading – did not increase brain activity, compared to pure mental imagery without stimulus in professional musicians, since these areas were already well-connected in the brain (Rossi et al, 2019), perhaps pointing to the hypothesis, that concurrent perception and mental imagery could indeed increase motor activations in young, less experienced learners, helping to link the correct sound with notation and movement. This, together with observation learning that can also be linked to mirror neuron system research (e.g. Rizzolatti & Craighero, 2004), would seem useful in developing mental training routines for young violinists.

Yet there are additional aspects identified in neuroscience that influence the learning and perfecting of a skill. In traditional mental training used by professionals, this is accomplished, in part, through progressive relaxation – a component of the mental preparation phase of mental training. In neuroscience reduction of stress, that can be also accomplished through concepts of relaxation and meditation, has been identified in assisting the regulation of an area of the brain called the posterior cingulate gyrus (Garrison et al, 2015), a part of the limbic system, malfunction of which can hinder access to long term memory. Indeed, areas of the brain that are activated during stress – such as the limbic system – act to filter out any information not considered important for survival, initiating the so-called ‘fight or flight’ response (Perry, 2006). Thus, examining the processes connected to mental training and learning can assist in devising approaches to teaching and learning. These can include the concept of expansion of ease: with awareness that the language used and the concepts discussed can also create spontaneous mental imagery (see Kosslyn, 1990; McCrum, 2016). Indeed, this too can create a stress response, especially if it produces imagery of difficulty or pain (Hishitani, 2011). It is perhaps not surprising, then, that a reduction of teacher verbal instruction has been identified as an effective method in sport for reducing interference (Gallwey, 1974).

In fact, the construction of a student's own mental model of the task at hand appears to be paramount in learning – a concept that appears in the writings of J. S. Bruner, who identified *"three systems of processing information by which human beings construct models of their world: through action, through imagery, and through language"* (Bruner, 1964, 1). This observation fairly accurately reflects the inclusion of mental training in the pedagogical process.

But how can mental training be included in the learning of rhythm and pitch on an instrument?

Cognitive aspects of intonation

Our previous research concentrated on the concept of creating and improving intonation on the violin and referenced research concerning the process of playing an instrument. In that study, a mental training routine was created based, in part, on the findings from cognitive neuroscience of playing a musical instrument, where the process of the creation of a mental model was identified. The mental model creation process started with a stimulus – score reading and/or observation – followed by creation of an initial mental model of combined sound/tone and rhythm. This is then realised in actual practice, at which point perception of the actual sound takes place and the physical playing is altered to match the mental model, and/or the mental model is adjusted, reacting on the experience created by the physical realisation of the sound (see Zatorre, 2007; Gruhn, 2015).

The mental training routine also incorporated concepts presented in sports research – that mental imagery in enhanced with movement (Guillot et al, 2013) and in neuroscience – that a major aspect in developing instrument-playing skill is the auditory-motor coupling (Kajihara et al, 2013). Concepts including approach: the language used in the pedagogical process and the elaboration ease in technique using personally-relevant metaphoric imagery, were included in that mental training routine, followed by combined perception and miming of actions that create the music with the violin in hand.

As auditory and motor areas in the brain are inherently linked, it is possible to understand why the mental training routine not only improved intonation, but also rhythm. However, since the previous paper started from the viewpoint of intonation, this paper will examine mental training from the viewpoint of rhythm: to understand if it is possible or necessary to separate the two in mental training.

Neural Correlates of Rhythm

Research in neuroscience has identified that the ability to recognise and tap along to a beat in music depends on communication between auditory and motor planning regions of the brain – even in the absence of movement (Patel & Iversen, 2014). The quasi-innate ability of perceiving a beat – stronger in humans than other species, including primates – is supported by motor planning neural structures that simulate periodic movement, transmitting an impulse to the auditory system that predicts the timing of forthcoming beats. This creates a two-way pathway between auditory regions and motor-planning systems. Patel's & Iversen's *"Action Simulation for Auditory Prediction Hypothesis"* (2014) is significant in devising a mental training routine for rhythmic awareness, since their observations not only relate to similar processes sought deliberately in mental training, but also highlight an important aspect of rhythm processing: that it sets up precisely-timed beat-related expectations; to understand the beat, it needs to be predicted (see Figure 1). This understanding is flexible – a beat can be faster or slower and perception is adaptive. More specifically, the researchers noted that the brain's motor planning system simulates movement of periodic body movement patterns, in a beat tapping exercise.

More recently, research has revealed that beat perception creates cortical oscillations at the same frequency as the beat in music and this occurs even if a beat is omitted from the auditory stimulus, confirming that neural activity at the same rate as the pulse is generated internally, rather than occurring purely as a reaction to external stimuli (Tal et al, 2017).

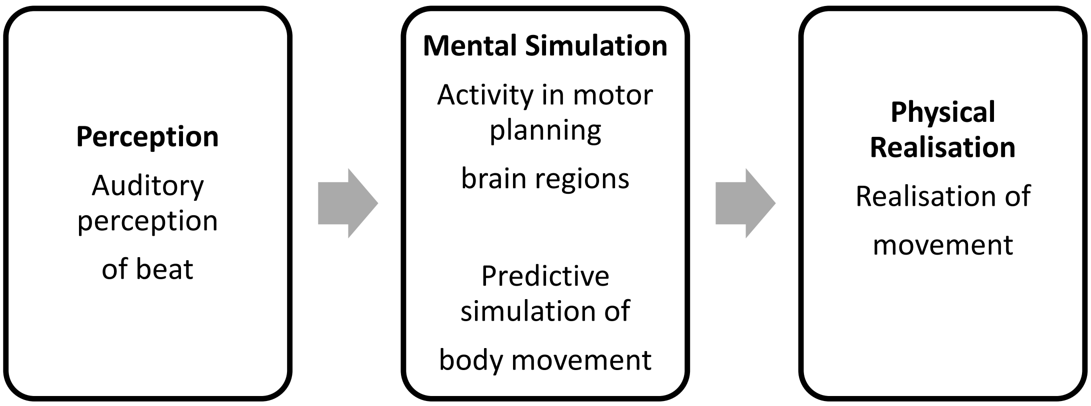

Figure 1. Process of beat cognition (diagram based on Patel & Iversen, 2014; Tal et al, 2017)

These discoveries lead to questions about the nature of mental training routines for the development of rhythm. The explanations of the mental processes connected to learning and those connected to mental training lead to the realisation that mental training needs to consider both the deliberate use of mental imagery and its spontaneous creation. Playing an instrument creates the spontaneous formation of neural structures that connect to the concept of the mental model, but its creation is spontaneous. Awareness of these spontaneous activations and working on them deliberately could indeed assist in creating informed mental training routines.

Could a mental training routine for the development of rhythm, therefore, be based on the alternation of physical production of sound on the violin with auditory perception that can help to bring into awareness the predictive nature of pulse? What would be the effects on rhythm and intonation of an exercise like this? Additionally, what would be the removing the violin, and simply imagining the process of playing the violin through mental imagery and replacing the sound of the violin with perception/production of vocalisation of the sounds required? To develop these concepts into actual mental training routines, it is first necessary to identify aspects of these in the existing violin literature.

Alternation of Physical and Mental Aspects in Violin Literature

Though rare, alternation of physical and mental components can be traced in the violin literature. Collins (1962), in her handbook for class violin teachers, suggested a set of so-called 'drills' for the development of pitch, two of which are of particular interest to this study. The first involves silent trill exercises – where the students use the fingers: 0101, 2121, 2323, 4343, whilst vocalising the finger number as it is used. The teacher, meanwhile, plays the sounds on the violin and encourages the students to sing the number of the finger. She notes that if a student cannot be persuaded to sing, the pitch of their voices however seems to alter as they 'speak' the finger numbers. Additionally, she notes that if the students start playing *pizzicato*, the process of vocalisation is simplified. The goal of the exercise is to train the students to *"hear the pitch of the sounds inside their heads"* (Collins, 1962, 67). Her second significant exercise again to be carried out within a set of finger 'drills' - this time with sound – involves dropping the finger of the next note to be played and before actual playing the student is asked to imagine the sound. This is followed by checking to see if they had attained the correct note mentally, by actual realisation of the note with *pizzicato*.

These two exercises are significant, in that they encourage the use of mental imagery and anticipation, though not described as such by the author. Whilst there is little doubt that Collins' first exercise could assist in the production of auditory mental imagery, the second exercise may, in fact, be useful in developing concepts of rhythm, since it alternates actual sound with imagery predictive of sound, as identified in the neuroscientific literature in connection to rhythm. Interestingly, the exercises the author describes are designed to be presented to the students without musical notation - and rather than being used as a tool for learning new repertoire, they are used as technical exercises *"allied to pitch"* (Collins, 1962, 68). Their description of being 'drills' also perhaps defies the premise of mental training, having the danger of losing the personal interest of the student. Musical notation in Collins' method is only introduced after the students have repeated all of the 'drills', and after being able to sing the pitches of the notes, instead of the finger names. Overall, they are connected to mental training, but approached through the concept of physical work, which is perhaps consistent with the decade in which they were written.

However, violinist and pedagogue Galamian (1962), in the same year writes that the foundation of technique-building lies *"in the correct relationship of the mind to the muscles"* (p. 5) and labels this concept the mental-physical relationship, correlation. He notes that technical mastery is not controlled by the strength of the muscles, but by their response to the *"mental directive"* (p. 6). In a series of rhythmic and accented patterns, he attempts to improve 'correlations' of mind and muscle response. Interestingly, Galamian does not elaborate on these exercises in detail, even describing them simply as co-ordination exercises later in his book and so it is possible that the significance of these exercises is often overlooked. The rhythms presented – starting with a dotted quaver, followed by a semiquaver in the first exercise – have the effect of allowing the student to prepare mentally on the longer note for the next note(s). The rhythms gradually become more complicated – such as a dotted quaver, followed by three semiquavers in the third exercise, but still allow the student to mentally prepare, using both auditory and motor imagery, for the next group of notes whilst playing the longer one.

Interestingly, Galamian's correlations are also designed to be used in violin repertoire being learnt by the student, and rather than purely increasing technical demands, Galamian is effectively training the concept of simulated movement or mental imagery during the playing process, that can now be identified in the neuroscientific and mental training literature as being significant. In fact, the rhythms have the effect of shifting focus of the beat, so that the student creates a mental bookmark for each note – from which he or she can now proficiently move to the next, creating a quasi-mental framework of the repertoire.

Whilst Galamian's methods are designed for more advanced students, the essence of alternation of mental and physical is actual in the creation of mental training routines in with primary school violinists.

To assist in identifying the differences in student playing pre-versus post mental training, it is necessary to conceptualise the intonation used in violin playing.

The Peculiarities of Violin Intonation

Accuracy of intonation has been described as *"the ability of musicians to perceive slight variations in pitch and make the corresponding adjustments in their own performance"* (Salzberg, 1980, 42). Interestingly, violinists rarely intonate to the equal temperament of the piano, except when playing in unison with it (Whitcomb, 2017), but rather use a mixture of Harmonic (Just) intonation and Melodic, (Pythagorean) intonation (Sassmanshaus, 2012; Keyes, 2013; Whitcomb, 2017). Harmonic/Just intonation has a ratio of 5:4 for major thirds, meaning that against a pitch of 400 cycles per second, a major third is 500 cycles (Whitcomb, 2017). This type of intonation is used in chordal passages and in string quartet playing. It can be differentiated by its slightly lower thirds compared to Pythagorean, where the major third has a ratio of 81:64 (Siljestam, 2013) and is also characterised by narrow semitones and large tones (Sassmanshaus, 2012), since it is based on the tuning of fifths (3:2) and octaves (2:1). This type of intonation is used in solo playing in order to give melody direction (Whitcomb, 2017).

Thus, the intonation used by professional violinists has a range that can be measured from equal temperament. Our previous study found that intonations of four professional violinists displayed very few notes under equal temperament – the lowest being about -18 cents, based on a semitone being split into 100 equal parts. More frequently, the intonation would be raised, being influenced, perhaps by the tradition of *Pythagorian* intonation in solo playing. The highest intonation detected in the sample was +46 cents. This data is useful when assessing student intonation, since it provides a concept of the ideal range of violin intonation. A reduction in both overall range of intonation and the number of notes with intonation below zero in equal temperament pre-versus post-mental training can indicate an improvement in intonation, therefore.

From analysis of the combined literature in neuroscience, pedagogy, mental training and violin pedagogy, it can be inferred that a mental training routine aiming to develop auditory-motor processes for the improvement of rhythm and intonation should include:

- Aspects of ease and personal relevance, to facilitate the neural processes connected to learning and increase personal interest in the subject content;
- Reduction of teacher verbal instruction, to reduce interference and assist in creating the student's personal mental model;
- Auditory stimulus alternated with practical realisation, to facilitate the creation of predictive motor and auditory mental imagery;
- Shifting the focus of the beat, to assist in creating an awareness of each note, and how to prepare for the forthcoming note(s);
- Incorporation of reading from musical notation, to assist in connecting auditory imagery of the required sound to the visual perception of the written notation.

Methodology and Sample

In order to assess the effects of mental training on the development of pulse and intonation, it was necessary to collect relevant data pre- and post the mental training conditions. Initial analysis was carried out using the software *Melodyne 4*, running on a Macbook Pro. IBM SPSS Statistics 21 was used to conduct statistical analyses on the data collected.

The software *Melodyne 4* has the following functions relevant to the analysis of both intonation and rhythm:

- Detection of the overall tuning of the recording, adjusting to the individual tuning of the violin – i.e. whether A4 is tuned to 440 hz or 444 hz, etc;
- Distinguishes the pitch of each note played;
- Measures the distance that each note deviates from the same note in equal temperament (the measurement is made in cents, each semitone being split into 100 cents);
- Detection of average metronome pulse for a section, or for a selected note as selected by the user.

Nine violin students from classes 3 to 8 (=average age 11) from Cesis' First Primary School participated during their scheduled violin lessons. Duration of each lesson: 20 minutes.

The two mental training routines developed for this study were introduced in separate lessons, due to time constraints. The routines occurred after the lesson's introduction and verification that the students' basic needs had been catered for.

The students had not previously used these two mental training routines, though they had participated in a different mental training routine in the previous month. Whilst they were used to experimentation in lessons, the processes involved in these new routines had not been carried out previously. Additionally, the routines were not described as being 'mental training', since the terminology had not yet been introduced.

Baseline Measurements

Baseline measurements taken before the first and second mental training routines reveal that the students' ranges of intonation are wide (see Tables 1 and 2), which was also noticeable audibly during their playing. Therefore, a reduction in range would be an indicator of an improvement after mental training. Additionally, the intonation that is below zero in equal temperament needs to be raised and the intonation that reaches over about +45cents needs to be lowered, to be closer to the intonation used by professional violinists.

Similarly, the ranges of tempo in the baseline measurements show broad ranges of tempo, indicating that a concept of pulse had not yet been grasped by the students (see Tables 1 and 2). Indeed, their playing could be described as being "unsure" or lacking in fluency.

Table 1. Range of intonation and rhythm of students before the mental training routine "My note your note"

Student	1	2	3	4	5	6
Minimum Intonation (cents)	-47.00	-132.00	-102.00	-98.00	-51.00	-49.00
Maximum Intonation (cents)	116.00	42.00	8.00	2.00	39.00	12.00
Range of Intonation (cents)	163.00	174.00	110.00	100.00	90.00	61.00
Minimum Tempo (bpm)	3.00	14.08	50.04	19.49	40.96	27.77
Maximum Tempo (bpm)	58.42	143.54	107.20	115.35	304.00	128.01
Range of Tempo	55.42	129.46	57.16	95.86	263.04	100.24

Table 2. Range of Intonation and tempo of students before mental the training routine "fingers and thumb"

Student	1	2	3	4	5	6
Minimum Intonation (cents)	-102	-76	-160	-72	-112	-111
Maximum Intonation (cents)	21	50	30	518	107	63
Range of Intonation (cents)	123	126	190	590	219	174
Minimum Tempo (bpm)	39.260	27.6	30.45	16.56	13,71	45.190
Maximum Tempo (bpm)	88.970	110.820	85.73	86.39	71.8	157.58
Range of Tempo	49.710	83.220	55.280	69.83	58.090	112.39

Most students played the initial excerpt already from the musical notation, however, there were some students that generally preferred to try and play by ear. Whilst this perhaps indicated a good aural ability, it was noticeable that these students lacked a clear understanding of the exact rhythm and sound of the notes, which impeded fluency.

Mental training routines

Based on the conclusions from the analysis of the literature, two mental training routines were devised. The first was based on the literature connected to rhythm – on the alternation of action and anticipation, plus the shifting of awareness from one note to the next. It is conducted with the instrument in hand. The second routine was designed for developing awareness of intonation and is conducted away from the instrument, providing an introduction to the concept of mental rehearsal used by more experienced players. Both exercises were also based on the literature that supports the enhancement of mental imagery with movement and both included an element of perception, where more traditional mental training with experienced players may engage imagery alone.

Metaphoric imagery was used at the beginning of each mental training routine replacing the progressive relaxation found at the beginning of mental training exercises with more experienced players, students were encouraged to create their own imagery, to assist in relaxing the muscles of each hand thus creating more personal relevancy. It was also designed to expand of the concept of ease, identified as being helpful in learning.

Whilst the routines were designed to involve teacher-student collaboration, both routines were also designed to reduce teacher instruction, in order to reduce interference of student thought processes, and to assist the student to build his or her own cognitive processes.

First routine: "My Note Your Note"

Designed to bring to awareness pulse and rhythm, this routine involves selecting a musical phrase of two to four bars, depending on the difficulty or tempo of the passage, so that the student feels comfortable with the length of the excerpt. The routine was designed to be carried out whilst reading the notes form the musical score and consists of five parts:

1. Initial playing of the excerpt by the student (from which the baseline measurements were derived);
2. The phrase is divided between teacher and student: the teacher plays one note, the student plays the next (see figure 2): the whole phrase is complete in this manner;
3. The process is then reversed: the student starts with the first note and the student plays the next;

Figure 2. "My Note Your Note" alternation of teacher and student playing

4. The student alone plays the whole excerpt as in step 1;
5. The student describes the differences they noticed between stage 1 and stage 4 and is encouraged to comment on the routine itself.

Second routine: "Fingers and Thumb"

1. Initial playing of the excerpt by the student (from which the baseline measurements were derived);
2. Without the violin, the student is asked to make a ring-shape against the thumb, using the correct fingers as required by the musical score. At the same time, the student sings the finger names at the same pitches as notated in the musical score. The teacher does the same in unison with the student;
3. The student takes the violin and plays for a second time;
4. The student is asked to reflect on the differences noticed between stages 1 and 3 and to comment on the exercise itself.

Teacher Observations during the Mental Training Routines

At the beginning of the *My Note Your Note* routine, students had a tendency to hesitate as per the first play-through, but after the student had found the note and played in confidently, the teacher continued with the next note in the same pulse that had been established at the beginning of the routine. This was carried out in accordance with the literature which revealed that the understanding of pulse, which includes its prediction, gets modified and adjusted in real time, during the process of pulse perception. Students indeed, reacted by playing the next note more accurately in the tempo as implied by the teacher's playing and therefore also the tempo that had been established at the beginning of the routine.

During the *Finger and Thumb* routine, some of the students were reluctant to start singing at first. However, since the teacher was singing and doing the exercise along with the student, most students began to sing after the first few notes. Additionally, students did not always produce a ring-shape with the fingers and thumb, but an ellipse. This was brought to attention by the teacher at the beginning of the routine. The students were then encouraged to place the fingers against the thumb, in the same way as they would place the fingers upon the fingerboard of the violin: to create a virtual image of the feeling of the violin in the hand. An additional observation during the second routine, was that the students seemed to work on slightly shorter passages than in the first routine, which was possibly due to the fact that it was a new and unusual activity, to *"imagine playing the violin,"* or possibly that they felt more motivated after the imaginary condition to pick up their instruments to see how it would sound again for real. In short, the students showed increased motivation to pick up their instruments and start playing.

Results

A. Comparison of the results before and after mental training

Routine 1: 'My Note Your Note' results

Whilst there were audible improvements in fluency, a Wilcoxon Signed-Ranks Test confirmed that four out of five students had statistically significant differences in tempo pre-versus post- mental training (see Table 3). As predicted, the routine assisted in developing a sense of rhythm and pulse, more than intonation. However, student 4, whose rhythm had not statistically changed (Z = -.604, p = .546), showed a statistically significant change in intonation (Z= -3.502, p <0.01), indicating that for some students, the mental training routine may bring concepts of intonation into awareness more than rhythm.

Table 3. Wilcoxon Signed Ranks Test before and after mental training routine 1 '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]	-2.657[b]
	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

Applying the Wilcoxon Signed Ranks Test on the data from all six students together revealed that both intonation (Z = -2.084, p = 0.37) and tempo (Z = -2.644, p = 0.008) had significantly changed pre- versus post- this mental training routine, though evenness of tempo showed a greater overall improvement.

Routine 2: 'Fingers and Thumb' results

Audible improvement of intonation was noted, especially on the notes that were completely inaccurate in the first play-through (stage 1 of the mental training routine).

This was reflected in the reduction of ranges of intonation pre- versus post- mental training routine in four out of five of the students (see Figure 3).

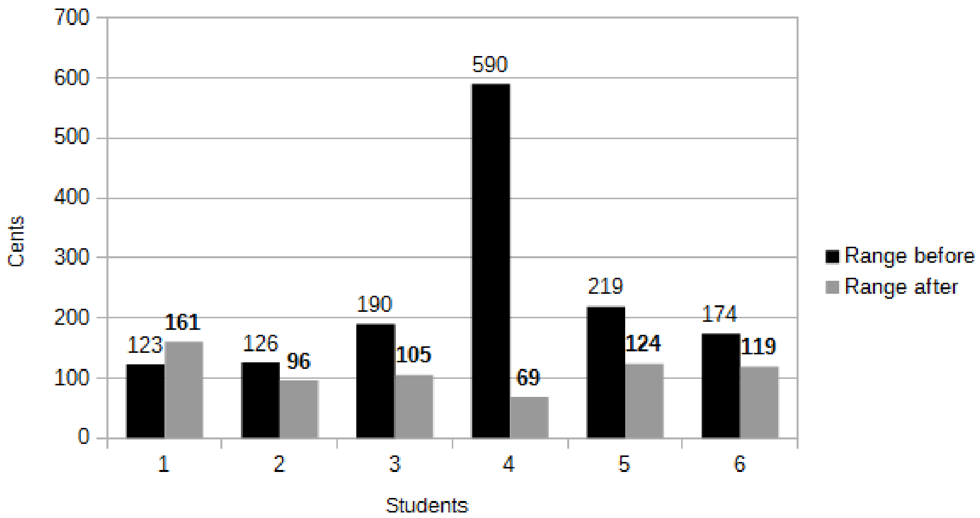

Figure 3. Ranges of intonation (in cents) pre- and post- mental training routine 2

Comparing the means and the standard deviations for intonation pre and post the '*Finger and Thumb'* routine, it is possible to conclude that intonations for five out of six students had become more neatly placed around their personal average (mean) intonation, that intonation was becoming more controlled (see Table 4).

Table 4. Mean and standard deviations: Intonation before and after routine 2

Descriptive Statistics

STUDENT		Mean	Std. Deviation	N
Student 1	Intonation before	-30.59	35.166	17
	Intonation after	15.24	38.983	17
Student 2	Intonation before	-28.82	31.726	17
	Intonation after	-11.35	29.776	17
Student 3	Intonation before	-44.97	47.381	29
	Intonation after	-30.14	27.364	29
Student 4	Intonation before	12.71	146.839	14
	Intonation after	-18.93	18.951	14
Student 5	Intonation before	-11.89	82.829	9
	Intonation after	15.56	39.154	9
Student 6	Intonation before	-8.55	30.400	40
	Intonation after	-11.50	23.854	40

A Wilcoxon Signed-Ranks Test applied on the combined data for all of the students revealed that overall intonation for all of the students showed a significant difference in intonation pre- versus post- the mental training routine (Z = -4.000, p = 0.000063) compared to tempo (Z = -1.586, p = 0.113), the differences pre- and post- mental training routine for each individual student revealed only two students displayed individual statistically significant results (see Table 5). This may have been caused by the shorter musical excerpt included in this study, creating fewer data.

Table 5. Wilcoxon Signed-Rank Test: Intonation before and after routine 2, individual students

Test Statistics[a]

STUDENT		Intonation after – Intonation before	Tempo after – Tempo before
Student 1	Z	-3.623[b]	-.536[c]
	Asymp. Sig. (2-tailed)	.000	.592
Student 2	Z	-1.603[b]	-.876[c]
	Asymp. Sig. (2-tailed)	.109	.381
Student 3	Z	-2.335[b]	-.865[b]
	Asymp. Sig. (2-tailed)	.020	.387
Student 4	Z	-.944[b]	-1.160[b]
	Asymp. Sig. (2-tailed)	.345	.246
Student 5	Z	-.949[b]	-2.194[b]
	Asymp. Sig. (2-tailed)	.343	.028
Student 6	Z	.000[d]	-.921[b]
	Asymp. Sig. (2-tailed)	1.000	.357

a. Wilcoxon Signed Ranks Test
b. Based on negative ranks
c. Based on positive ranks
d. The sum of negative ranks equals the sum of positive ranks

B. Student reflections

The final stage of each mental training routine included student's commentary. Many of the students were surprised to find the routines had made playing the relevant sections of repertoire easier. Some of them remarked that it was simply 'good'. One of the students asked: *"How did that happen? That section is so much easier now!"* When the same student was asked why this is so, the student replied that it is not really possible to describe it in words and that *"I just seem to know what to do next"*. Another student said that the music was now more understandable. Overall, comments were positive.

Discussion

The mental training routines in this study were designed to include aspects of perception, combined and/or alternated with physical realisation and imagery, in order for the students to gain an experience that could form the basis for later use of imagery.

It was noticeable that in the months following the mental training routines whilst students were waiting for their lessons, they started to read their musical notation with or without the instrument in hand, and engage in silent practice. This was not previously observed before the mental training routines had taken place.

The statistical results of the mental training routines are interesting, whilst the results for the rhythm fairly accurately reflected those observed in the classroom, the statistics seems to reflect less strongly the effects noted by the teacher on intonation. That is, improvements in intonation seemed much greater to the ear compared to the significance that statistical analysis revealed. This suggests that statistical analyses may not reveal the full picture concerning intonation, especially the analyses that are based on mean values, since a student may play with intonation that is both very high (measured by cents in positive values) and very low (minus values), creating a mean value that could actually be in the same range as the mean value of professional violinists. Listeners, however do not average out the notes that they are listening to in a performance, but rather listen to each note individually. Even one or two notes played incorrectly may disrupt an otherwise enjoyable performance. Overall range, therefore, which is less strong statistically, is perhaps one measure that can assist in representing the human experience of intonation, as is, the standard deviation from the mean, as cited in the present research.

Conclusion

Results indicate that the different types of mental training routines can indeed assist in improving aspects of rhythm and intonation separately. That alternation of perception and action can improve rhythmic components of playing, suggests that purposefully exteriorisation of inner mental processes can assist in this process. That intonation can be improved through a combination of mental imagery; vocalisation and movement away from the instrument may indicate that intonation is as much cognitive as it is practical. Generating personally-relevant imagery for achieving a feeling of ease may also have facilitated more efficient mental and physical processes connected to playing.

Future studies could explore combining the two mental training routines in the one session and perhaps also on the same passage of music, though this may require longer lesson durations.

The results support the hypothesis that mental training routines can be designed to improve rhythm and intonation separately in the primary school violin teaching and learning process.

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