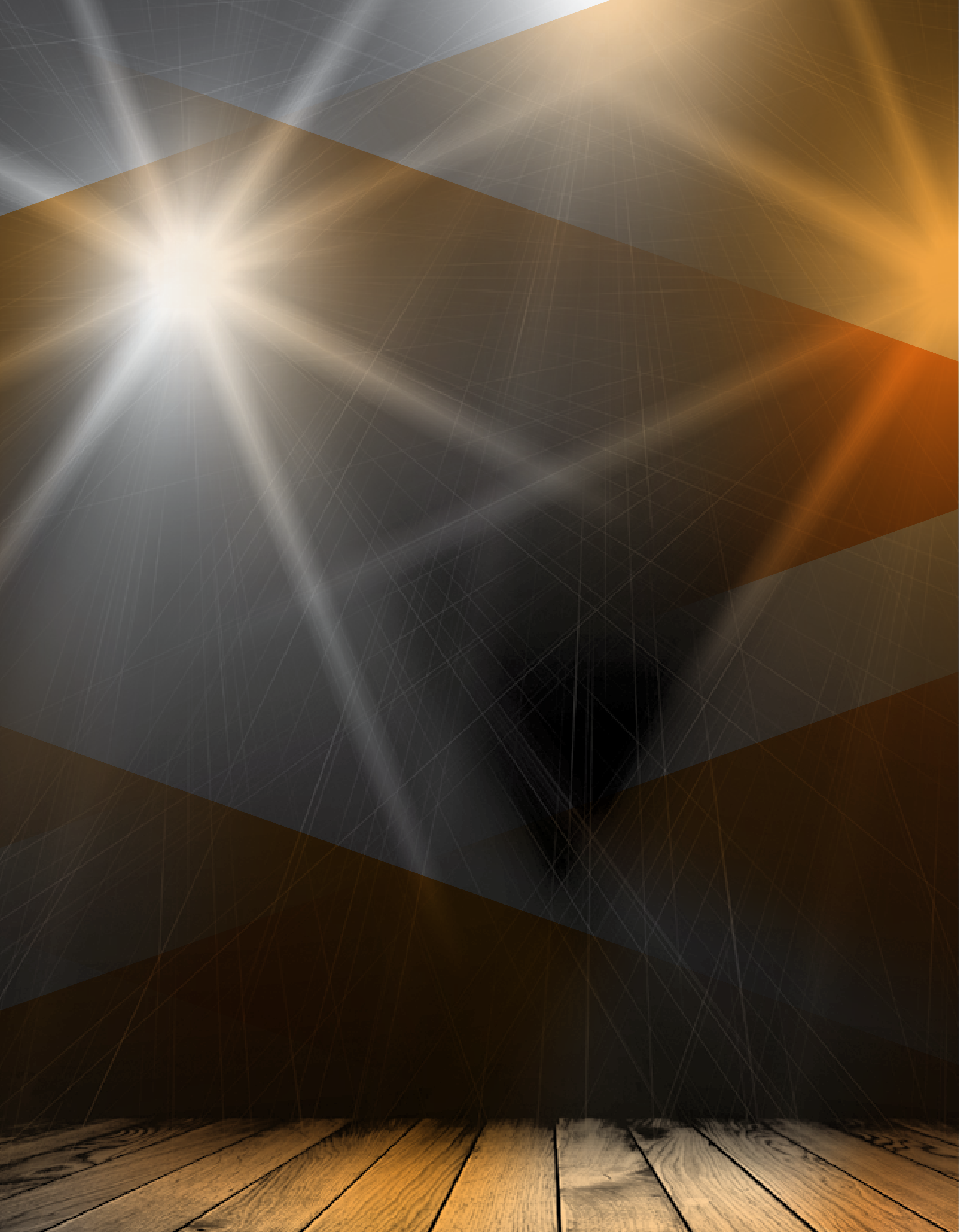
From potential to performance

Training Practice and Performance Preparation in Conservatoires

Koninklijk Conservatorium
Royal Conservatoire

Royal Conservatoire publications



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Contents

Foreword

Faculty research at the Royal Conservatoire The Hague focuses on a wide range of topics relevant to the artistic practice of its teaching staff, to the artistic development of its students and to the world of musical practice at large. Areas covered include informed performance practice, creative (artistic) research, instrument building, educational research, and music theory. One strand within the faculty research programme is directed towards the enhancement of the learning, practice and performing strategies of instrumentalists and vocalists. Two projects within that strand – 'Mental Training for Performers' by Susan Williams, and 'Making Music, Practising and the Brain' by Wieke Karsten – formed the occasion and motivation to organise the international conference 'From Potential to Performance: Training Performing Musicians in Conservatoriums' at the Royal Conservatoire, 11-13 October 2013.

This publication collects knowledge, insights and practical recommendations addressed at the conference by an outstanding group of scholars and practitioners. Some contributions to this volume were published earlier as articles in their own right, some have been written for the occasion. Combined in this publication they offer a rich and thorough account of the state of the art in this emerging research field.

The study of the relationship between musical practice and the physical and mental condition of its practitioners goes back to ancient Greek, to Plato's *Politeia* or Artistotle's *Politika*, where music, body and mind were conceived of as constitutive of *ethos*, i.e. of character, behaviour and morality. And throughout history that relationship between music, body and mind was thematised in ever-different ways; from the proto music psychology of the Baroque *Affektenlehre* to the Musico-Medizin speculations of the early 20th century. Only in recent decades the study of 'performance science' has advanced to the level of a serious research programme, rooted in both artistic practice and in cutting-edge scholarly and scientific work, combining insights from sport science, neuro-psychology, brain science, pedagogy and musical practice.

The Royal Conservatoire does not only want to profit from this emerging field of research, but also aspires to contribute insights and experiences, embedded in its higher music education culture and embodied in the professionals who study and work here. With the publication of 'From Potential to Performance' we support the dissemination of knowledge and understanding, but we also show our commitment to the research programme and our readiness to be in front of the development. In doing so the Conservatoire manifests awareness that today's higher music education is in constant need to refine and attune its programme to an ever-changing world.

Henk Borgdorff, Professor of Research in the Arts
Royal Conservatoire The Hague

Conference Programme
11/13 October 2013

From Potential to Performance

Friday: Overview of existing programmes

9.30-11.30	Brass clinic		
	Your Self as the Instrument; a Holistic Approach		Susan Williams
	How to Plan Practice		Erja Joukamo-Ampuja
	Practicing and Performing in Flow		Eve Newsome
14.00-14.15	Welcome & Introduction		Martin Prchal
14.15-14.45	Practicing and Performing at the KC	Koninklijk Conservatorium, Den Haag	Susan Williams & Wieke Karsten
14.45-15.15	Deliberate Practice	Hochschule für Musik und Theater, München	Prof. Dr. Adina Mornell
15.15-15.45	Musicians' Medicine	Hochschule für Musik, Theater und Medien, Hannover	Prof. Dr. Eckart Altenmüller
15.45-16.15	The Flow Music Method	Griffith University, Australia	Eve Newsome
16.45-17.15	Reflective Learning	CIT Cork School of Music, Ireland	Dr. Gabriela Meyer
17.15-17.45	Musicians' Health	Sibelius Academy, Finland	Dr. Paivi Arjas & Dr. Erja Joukamo-Ampuja
17.45-18.15	Sustainable Performance	Codarts Rotterdam	Frank Heckmann

Saturday: Practising and performing skills

9.30	Introduction		
9.45-10.45	Lecture	Musician's Medicine: state of the art	Eckart Altenmüller
11.00-12.00	Lecture	Motor Learning: what musicians can learn from sports psychology about motor learning, feedback and practice	Adina Mornell
12.00-13.30	Workshop	Healthy musicianship: how to practice New insights from brain sciences and sports psychology	Eckart Altenmüller
14.30-16.00	**Clinics/Workshops on specific themes**		
		Flow	Newsome
		The brain and the mind	Altenmüller, Karsten
		Memorization, Learning Strategies	Mornell, Mayer
		Mental training	Arjas
		Improvisation for classical musicians	Erja Joukamo-Ampuja
16.30-18.00	Feedback from the clinics and discussion with experts and participants	Teaching practising and performing	Susan Williams, Wieke Karsten

Sunday: Perspectives for the future

10.00	Workshop	"Deliberate Practice"	Adina Mornell
11.30	Discussion	Teaching and learning in the Conservatoire	Moderator: Henk Borgdorff

Guidelines for performers and teachers

Susan Williams

'We didn't ever talk about how to practice, injury prevention or flow – any of these things – where I studied before.'
'That's why you came here.'

Introduction

The conference 'From Potential to Performance' was motivated by a seminar that Wieke Karsten and myself attended in 2012, hosted by the Sibelius Academy in Helsinki (Finland). The few days of exchange with our colleagues at the Sibelius Academy, Cork School of Music (Ireland) and Griffith University (Australia) were extremely informative and inspiring for all concerned. When the suggestion came that we could host the next one at the Royal Conservatoire in The Hague, the seed was sown. A personal source of motivation for me was to gather some contextual material for my own doctoral research on the effects of imagery in training musicians. The need for a better understanding of how to practice and prepare for the stage is felt by most musicians, as the pressures of professional life are apparent, and even growing. In the sport arena, much discovery has been made which could be of benefit to musicians. A sports person preparing for the world stage has many hours of supervised training each day as well as regimes and advice concerning diet, general fitness and mental training. Conservatoriums generally cannot provide more than one hour per week of one-to-one tuition, so aspiring musicians must find much of this information themselves. In the last decade or so, many tertiary institutions are looking for ways to remedy this situation. This conference was an attempt to attend to this.

The conference was designed to address the following questions:
- How can a conservatorium provide supplementary material to the one-to-one lessons that a student receives?
- How can teachers access the latest information from the scientific world about motor skills, motivation and pedagogy?
- How can we (teachers) help our students to become self-regulatory and to optimize their practice time?

It was important to bring guest speakers who had not only knowledge on the subject of what is important for musicians' development but also could speak from their own experience of performing. For this reason we (the organising team) were fortunate that such prominent experts were each so ready and willing to give their time and energy. Each of the presenters has designed programs for their respective institutions and has a wealth of knowledge, experiences and observations to offer.

The unknown factor in the plan for this conference was the participants. Due to the insistence of the directorship to encourage teachers and students to attend and to the interest and curiosity of so many teachers and students of the Royal Conservatoire in The Hague, around 100 people attended. The event was engaged and engaging. Many questions (as well as some answers) and much interaction resulted which, together with very positive feedback, made it clear that the initiative was a success.

The conference opened with each guest presenting the work being done in his/her own institution. The seven institutions represented each have programs specifically designed to help students with their practice, performance preparation and health. The titles of each program reveal that each one has its own angle and personality. The Hannover University of Music, Drama and Media is home to the Institute of Music Physiology and Musician's Medicine (IMMM). Their emphasis is on treating and preventing injury, physiology and neurology. The Sibelius Academy has a similar profile and aims. The representatives of the University of Music and Performing Arts Munich (Germany) and the CIT Cork School of music, both offer comprehensive programs and emphasise learning strategies and techniques. Griffith University's contribution was in the topic of peak performance and the flow state. Codarts Rotterdam has developed a program based on the idea of sustainable performance. The Royal Conservatoire The Hague outlined its own set of electives encompassing performance preparation, the flow state, music and the brain and Alexander Technique.

Saturday's events included two lectures by Eckart Altenmüller, of The Hannover University of Music, Drama and Media and by Adina Mornell, of the University of Music and Performing Arts Munich. These, together with the thematic workshops in the afternoon and Mornell's Workshop on Sunday morning were rich with (more) information, insights and interaction. The conference ended with a lively discussion, moderated by Henk Borgdorff of the Royal Conservatoire, about the future of teaching and learning in today's tertiary music institutions.

This report attempts to formulate some of the most useful and important information and insights, which emerged throughout the conference.

Guidelines and key concepts for performers and teachers

> *'Once a comprehensive understanding of music learning is applied to teaching methods, a tangible 'science of practice' will emerge to replace the myths that surround the acquisition of musical skills.'*
> (Wulf and Mornell, 2008)

Identity

Eckart Altenmüller in his contribution 'Musicians' Medicine: A personal perspective', stressed the importance of treating the whole person. This would apply as much to teaching/coaching/training as to treating an injury or (mental or neurological) disorder. The need to embrace a holistic approach is linked to the fact that musicians generally experience their profession as a vocation rather than an occupation. Frank Heckmann, in his talk about 'The Journey', refers to this as 'The Calling', and gives space to this element in his workshops. Becoming a capable and healthy musician with a prospect of a long career involves having, or developing a clear sense of identity, self awareness and self knowledge, self efficacy and self confidence, and an idea of what you want to say as well as all the tools and techniques in order to be able to express this. Altenmüller pointed out that people who decide to become professional musicians tend to do this in their teens – much earlier than with other professions. Being a musician is closely linked to identity. For this reason, if something goes wrong, it can be experienced as catastrophic to a musician, as his/her identity is under threat.

Goals

> *'Research has made clear that people who have clear goals have more success than people who don't.' (Frank Heckmann)*

A recurring theme was the importance of goals. Focussing on and working with goals stimulates an integrated approach which helps develop efficiency, reduce practice time and strengthen motivation. Goals are also central to deliberate and reflective practice. Particular emphasis was given to short-term achievable goals, which facilitate both the learning process and enhance motivation and provide efficient performance preparation.

> *'Goal orientation is neurobiologically necessary for learning.'*
> *(Adina Mornell)*

In her discourse on Deliberate Practice, Mornell mentions that not only the long term goals are important, but the daily level sub-goals. It is important to know when they start and end (to understand when you begin and finish with working on a specific goal). 'When I get a benefit from achieving a sub goal, the body rewards me with dopamine.' (Adina Mornell)

For attaining and maintaining a 'flow' state goals are essential. It is important that they are challenging, relevant and not too boring or too unattainable.

> Q. (student): *'What can one focus on, rather than mistakes?'*
> Gabriele Mayer, of the Cork School of Music: *' Achievable goals. Tasks to get the feel good factor. Notice what you feel happy with and what you'd like to change [….] hearing the phrase in its ideal state. Knowing what you are going for and aiming for it and reinforcing with repetition and experience.'*

It was mentioned often and by various speakers that it is helpful to aim for a level that is slightly beyond your present level. Mayer spoke of the 'Sweet Spot' between the Comfort Zone and the Survival Zone, and *'reaching just beyond your possibilities'*. This relates also to the Japanese concept of *Kaizen* – continually looking for improvement, challenges and change – which Mornell mentioned in her talk on deliberate practice. *'Experts across the board are constantly looking for new ways to make what they practice difficult, in order to make what they do on stage easy.'* (Adina Mornell)

The Body

Without a body, we can't make music. Eckart Altenmüller gave detailed and elaborate information concerning the nature of injuries, their causes, treatments, and most importantly, prevention. The Music Medicine faculties of Hannover University, as well as its sister Institutions in Freiburg, Cologne, Berlin and Dresden, have extensive facilities to deal with these issues. The idea is that science should help musicians improve. Altenmüller outlined the structure at Hannover, which showed a relationship between teaching activities, research programs and an outpatient clinic. The Sibelius Academy has a similar profile. Both of these institutions have done surveys which reveal that a large percentage of students already start their studies with pain that deteriorates their ability to play (25% at IMMM and 33% at the Sibelius Academy). The musicians' medicine clinic in Hannover has admitted over 7000 patients since 1994. Altenmüller himself sees around 15 patients a week. Problems range from pain syndromes (mostly chronic pain), movement disorders, nerve compression syndromes, other neurological disorders, anxiety disorders, problems associated with hand surgery and others. Altenmüller himself is a renowned expert on focal dystonia. This is a loss of motor control of skilled movements necessary for instrumental playing, and affects 1-2% of musicians. Guitarists, pianists and flautists are most at risk, as the movements required are so fine, complex and quick. It has connection to anxiety and exaggerated perfectionism and most sufferers (78%) are male… The good news for people who have this condition, is that there has been much success in treatment. Focal dystonia is one of the many debilitating conditions that might be prevented if teachers and players are more aware of the triggering factors.

> Ergonomics was emphasised by both Altenmüller and Joukamo (of the Sibelius Academy). Unfavourable ergonomics can lead to pain. Many of our instruments were developed centuries ago and much of the repertoire we play today is considerably more physically demanding, resulting in an unhealthy situation when one holds and plays this instrument for many hours a day. (The subject of how long should one practice is mentioned later in this report.) *'Our body has to adapt to an old-fashioned interface.'* (Eckart Altenmüller)

In the brass and wind clinic, Erja Joukamo-Ampuja, of the Sibelius Academy, went into some detail about how to build muscular strength and endurance, and the phenomena of 'super compensation.' This is based on the fact that when you stop practicing, you start recovering. After about 24 hours of resting from playing, you not only are back in shape, but your body strengthens those tired muscles so that they are stronger than before. For this to happen, one needs to play a bit lighter every second day, and plan this into your long-term practice. It helps to plan a 'recovery week' each month, giving the opportunity for the muscles to replenish. It is important to incorporate this idea with repertoire and exercises. '[By resting] *you get it* [strength and endurance*] for free!'* (Erja Joukamo)

Different forms of body awareness and training techniques and disciplines such as Yoga, Feldenkrais, Alexander Technique and Tai Chi are offered in the various institutions which were represented. Physical fitness is important for everyone. Altenmüller is himself a fan of endurance sports and recommends running and swimming. Swimming in particular is beneficial for musicians.
There was, unfortunately, no body awareness or movement component in this conference. This can be a valuable topic for future events.

Learning and the brain

There were many insights into the nature of learning, and about how our brain functions from the perspectives of motor learning, neuroscience and pedagogy. An important example of why it is important to have some understanding of how the brain functions is that the brain does not distinguish between a 'good' note and a 'bad' note. We tend to learn what we focus on. If I am busy thinking 'Don't play a g sharp', then there is a good chance that g sharp is exactly what I will play… A clinic on the topic of 'The Brain and the Mind' was hosted by Eckart Altenmüller and Wieke Karsten (whose article on this subject is included in this publication).

Mental training is offered in all the represented institutions. The Sibelius Academy in particular gives an extensive module on the subject. Päivi Erjas gave a demonstration of the theory as well as exercises in mental training in a workshop at the conference. Mental training is useful for improving learning and to make practice more efficient, for memorization, to overcome technical difficulties and develop skills, to heighten sensory awareness, to help improve attention and confidence as well as communication. It is not only useful when physical practice is not possible (due to injury or whilst travelling or away from the instrument) or to avoid too much physical practice, it *enhances* physical practice.

Audiation is a topic that emerged during the conference and which generated lively discussion. When an audience member asked about the importance of inner hearing, Altenmüller answered *'Absolutely! Audiation – the ability to creatively produce sound in your mind. Attention to sound. Rendering a piece of music colourful. Many colours, complex mechanism of many movement patterns and much imagination.'* It was pointed out that inner hearing is expected to develop in student musicians but not usually actively taught. Altenmüller proceeded to tell a story about how he found a good sound. His flute sound was 'flat' but he couldn't hear it. One day, by making the right space in the aural cavity, he found it. 'I finally got the right "sound image".' He went on to explain '*Children should be helped to find this. The best examples [of musically gifted children] are those who have a kind of auditory fantasy and sensitivity and they have a good body awareness to find the best movement.'* To the question '*Do you link your inner hearing to movement?' he answered*
'*Yes. To have a certain sound quality, you have a certain gesture. This is very complex.'*
Working with inner hearing, like working with goals, stimulates an integrated holistic response from the individual. Noting 'this is what I want to hear', and imagining it vividly, stimulates the body to find a way to produce it. Several people (presenters and participants) saw developing inner hearing as a key to being a great musician.

Adina Mornell illustrated some of the most important findings from sports psychology which are relevant to musicians. These are reported in detail in the article by Wulf and Mornell in this publication. The main points that were made were the difference and significance of external and internal attention, the importance of random and varied practice, types and frequency of feedback and observational learning. An interesting aspect of much of this information is how *counter-intuitive* it is. This is why, even when we know random and varied practice is more beneficial, it still feels good to repeat sections until we get them right. This relates to the point made about differentiating between momentary performance improvement and long-term learning. and long-term learning.

Practice approaches, strategies and tips

Distinguishing between what improves performance and what improves learning

This is perhaps one of the most important insights that came out of this conference.

Adina Mornell pointed out that playing and performing music depends on motor control. Her presentations emphasize that we need to distinguish the difference between what enhances performance in the lesson or practice room, and what stimulates actual learning that can be recalled and presented on stage. We naturally want to be able to see improvement immediately and use methods that facilitate a 'quick fix.' Both the player, who can repeat a phrase until it works, or a teacher who too quickly gives helpful feedback before the student has registered the problem, can fall into this trap of thinking that learning has taken place.

Deliberate practice

Concert pianist, psychologist and pedagogue Adina Mornell explained the concept of 'deliberate practice' and how this approach can help musicians. Mornell has combined aspects of K. Anders Ericsson's expertise theory with material from sports science, psychology and performance science to address *'how to do something with your brain, with your heart and with your body which leads to the best result'*. The emphasis is on purposeful work. The three factors discussed from expertise theory were

1. That it's a specific type of work
2. Use of strategy
3. Involves goal setting

Learning blocks are important – you can't learn a whole piece at once, so you need to break it up. What can help is switching between different of blocks (variable practice), instead of repeating the same over and over again (massed practice). Within the concept of 'deliberate practice,' Mornell wants us to challenge the 'Natural Law of Least Effort.' Our energy-conservation rule states: 'If I can be lazy, I will. If I don't have to pay attention, I won't.' What defies this law is to be constantly striving to get better. The Japanese have a word for this: Kaizen.

> *'Deficit practice – looking for mistakes – is what most of us learned from childhood on. We need to look for new things we want to try out and experiment. Get away from the way you've practiced all your life. Find your own new ways*!' (Adina Mornell)

Mornell emphasises the need to take risks, and to practice what you can't do: *Amateurs practice what they can; professionals practice what they can't.*

Many of the participants seem to be moving away from the idea of concentrating on mistakes and looking for note perfect performances as a main goal, and tending towards concentrating on more holistic and global aspects such as the sound itself, the gesture of the music and communication. These things help to efficiently organize the brain and body to produce more accurate and technically stable performances.

Reflective practice

Gabriela Mayer, of the CIT Cork School of Music, discussed effective practice strategies in great detail in her lecture about mindful practice and better learning. This presentation offered many alternatives to (inefficient) approaches that many of us have absorbed in the past. The most important points are included in her article, which is included in this publication. Both Mayer and Mornell spoke often about 'chunking' – the brain responds well to learning in achievable chunks. Mayer presents a concept of a spiral of learning which consists of intention, execution, active listening, reflection, repetition, consolidation/calibration and leads back to intention. What is emphasised is taking the time to reflect and consolidate before starting the next cycle. Mayer's aim is to produce autonomous students who are capable of self-regulation.

Altenmüller also pointed out the importance of self-management and self-motivation as important factors in skill development.

> *'People are practicing too much!'* (Eckart Altenmüller)

How much practice is enough?

Many musicians, when not practicing, feel guilty. The Trumpet Guild Magazine in the 90's warned in an article about preparing for auditions '[…] and remember, when you go to bed tonight […], someone else is still up practicing!' Added to this is the concept of 'no pain, no gain' – which Adina Mornell thankfully pointed out in her first lecture*, is a myth*. Altenmüller showed some statistics, which illustrated what he called 'The Penelope Effect.' In practice trials of skilled finger movements, it is revealed that after around 150 repetitions, *the skill got worse*. Most musicians have experienced this phenomenon themselves during (over) practice. *'The brain gets bored'* (Altenmüller).

The general consensus (and good news for many) was that between three and four hours of (good) practice is plenty. Absorbing this fact could lead to a great deal less guilt (and less injury) for many musicians.

Finding Fellows and Making Friends

Fellowship is one of the five aspects that make up 'The Journey' – a series of experiential workshops designed by Frank Heckmann, of Codarts Rotterdam, to enable musicians to explore how to perform at their best. Fellowship is the second part of the journey, and is based on the concept that we humans are hardwired to work together and therefore need to utilize this social intelligence. During Heckmann's workshop the participants of the conference were invited to gather together on the stage and do an exercise involving going into pairs and on putting their hand over the top of the second person's hand and allowing themselves to be led by the movement of the other. Then switching roles. Participants noticed things like experiencing connection, noticing subtle things with all the senses, and how it feels to lead, or to give up control.

> *'Look at the whole – don't just look at the shoulder.'* (Eckart Altenmüller)

A case study

The importance of friendship was highlighted by Altenmüller in his detailed description of a case study involving a young violinist. The severe shoulder pain that had persisted for more than 18 months and was unsuccessfully treated by many different specialists using various techniques landed eventually in Professor Altenmüller's clinic. His treatment was many faceted, and a pivotal factor was recognizing that the young (and very talented) man was alone. He was in a foreign country, couldn't speak the language and had no friends. Added to this was a lack of intrinsic motivation. He was never asked if he wanted to play the violin and was the product of ambitious parents. Part of Altenmüller's advice was 'Go and make friends. Learn German. Go to some classes and talk to people.' Previously the student had only spent time in the practice room and was talking daily with his mother on the phone in his native language. The story had a positive ending, if not a little unexpected. The student learned German and went on to study law, entered a law career and enjoyed playing the violin as an amateur – with no pain.

Flow

Mihaly Csikszentmihalyi's research on flow has stimulated a huge growth of interest in 'positive psychology' throughout the world. His theory can be used and adapted to help people experience more happiness and achieve better work satisfaction. It can also lead to high achievement and peak performances in sports and in the performing arts. During the conference, two very different applications of the flow research were revealed. Eve Newsome's 'Flow Music Method' connects closely to Csikszentmihalyi's theory which includes nine elements of flow: merging of action and awareness, concentration on a limited field, balance of challenge and skill levels, paradox of control, loss of self consciousness, clarity of goals and action, clear feedback, autotelic experience and altered perception of time. (See Newsome's article in this publication for more details). Newsome has adapted techniques for exploring these elements as ways to invite and to enter the flow state, by focussing on goal setting, body awareness and connection with the instrument, exploration and problem solving and enjoyment (an overarching factor). Her own research, which involves testing the effects of a practical application of flow theory on instrumentalists, is presently underway.

> *'You cannot get to this "flow consciousness" with cognition.'*
> (Frank Heckmann)

Frank Heckmann's 'Sustainable Performance' is an approach which combines elements of Csikszentmihalyi's flow research with his own insights from social science. Heckmann's research with Csikszentmihalyi resulted in his formulation of the social conditions, which support flow:

- A socially supportive environment, and
- Decisional attitude: the ability for human beings to sense and perceive that they can have an effect on what they do.

He then found a structure for implementing these after reading the work of anthropologist Joseph Campbell. The book 'The Hero with a Thousand Faces' provided the framework for an archetypal setting to explore the themes of the journey every outstanding musician goes through. Again and again. This cyclical journey has 5 stages:

1. The Calling: is where you become more aware of your purpose, goals and qualities
2. Fellowship: finding allies and connecting with others
3. Dragons: Becoming objective and looking at how you cope with difficulties and facing your own dark side
4. Performance: Stepping in the middle of the moment. The most important learning environment
5. Return: Descending from Mount Olympus back into daily life. Bringing back what you have learned and experienced and sharing it. This is an important transition to becoming a new version of yourself before you start the cycle again …

Heckmann used this formula for the Dutch Olympic team that went to Athens in 2004 and more recently at Codarts Rotterdam where he worked with 40 people (mixed instruments, dance, teachers as well as students) for two and a half years. Participants reported more frequent flow experiences both individually and in groups.

> *'Enjoyment and positive experience leads to a higher performance level.'*
> (Eve Newsome)

Enjoyment, engagement, curiosity and enthusiasm stimulate learning and enhance performance. Although fun and play are ruled out by Ericsson and the by the purists who advocate deliberate practice, Adina Mornell includes these in her own version. In fact all of the presenters mentioned the importance of positive emotions.

> *'It is important that we have this emotional part of making music more in focus and that we consider music as communication and not the right amount of correct notes.'* (Eckart Altenmüller)

The Popular Neuroscientist Gerald Hüther explained the importance of enthusiasm and engaging the emotional centres of the brain in order to learn and teach effectively. He said *'Our jobs as therapists, teachers or parents is to invite. If this is not enough, then we must encourage (this has greater emotional loading). If this is still not enough, we need to inspire.'* He went on to explain *'In order to invite, we need to know what we are doing. In order to encourage, we must love the other. In order to inspire, we need to* be *inspired.'**

* From a psychotherapy conference 'The Brain and the Soul', Amersfoort, 2011

Performance preparation

> *'Practice has nothing to do with performance. […] Performance is a learning environment in and of itself.'* (Frank Heckmann)

Several of the presenters pointed out that being able to play well, does not ensure a good performance. Preparing for the stage requires practice and experience in performing. There are, however, many techniques and practices that can help the preparation. Päivi Arjas (full time teacher of performance coaching) outlined the courses offered at the Sibelius Academy. These courses explore the physical and mental aspects around performing, including arousal, breathing, relaxation, concentration, self-confidence, identity, thinking and the power of suggestions and affirmations. Mental training is taught in this course. In the practical part of the course, the students are invited to try out many techniques in a small group. *'It's one thing to discuss these things, and another to do them'* (Päivi Arjas). A new third course has been added which aims to bring artistically ambitious programs to audiences that are not used to listening to concerts. This is part of the Sibelius Academy's outreach program.

> *'Every performing opportunity is a step along the way and not the goal.'* (Gabriela Mayer)

Gabriela Mayer pointed out the importance of knowing what kind of practice you are undergoing – whether it is to develop a certain skill or to prepare a performance. Some tasks require ruthless precision ('hard skills') and others a flexible, adaptive approach ('soft skills').

Conclusions and Perspectives for the Future

An expanding field

Research by performers, teachers and scientists targeted at understanding how to acquire technical and performing skills is resulting in an explosion of activity on this subject. Especially interesting is that the various fields (performing arts, neuroscience, pedagogy and psychology) are often collaborating, resulting in benefits for all. Aaron Williamon at the Royal College of Music in London has coined the phrase 'Performance Science' for this rapidly growing field. Two conference series illustrate this. The International Symposium on Performance Science stages a 2 yearly event. In 2013 this took place in Vienna and the 2015 conference will be in Kyoto (Where the theme will be performance science and education). Adina Mornell hosts a yearly conference called Art in Motion which features leading researchers involved in the research of motor learning and its applications to musicians (the next one takes place in Munich on 29-31 May 2014 with the theme 'Performing Under Pressure.' Both of these conference series are experiencing an increasing interest.

In the final discussion the question was posed to the panel of experts and to the participants in the audience 'How important is the information presented here to musicians, students and teachers?' There was a general consensus that topics concerning how to practice, performance preparation and injury prevention are of enormous importance and should be included in the curriculum of a tertiary music institution. Some argued that it need not be compulsory. It was suggested that an overview should be compulsory and that students could choose to go deeper into these topics in elective subjects. Eckart Altenmüller, however, was adamant *'It must be compulsory!'* He is reminded of this daily at his outpatient clinic.

Gabriela Mayer, during her presentation frequently said *'Of course most of you know this.'*

> Do we??

Note

It must be mentioned that the message of some topics covered fit easily into a lecture or short workshop, but for some this format does not give them justice. Particularly the subjects concerning flow and sustainable performance need to be experienced deeply in order to be fully grasped. In any case, there was an abundance of information, insights and strategies brought to this conference, which were very convincingly conveyed by the guest speakers. The amount of information presented in this conference was too much to be absorbed in just three days. The articles in this publication, as well as the facebook site and website which will be created this year will hopefully provide a platform for musicians and teachers to absorb any relevant material at their leisure.

Performing and Teaching Musicians in the 21st century

Is the DNA of a conservatoire fit to the changes that need to occur in order to support artists and for culture in the 21st century? This question was posed by Frank Heckmann, who himself has tried to answer it with his innovative Sustainable Performance program. Gabriela Mayer described the difference between the traditional master-apprentice model and a more proactive approach where the teacher is sometimes a coach and not always the master. She reminded us *'The goal at the end of the day is to create independent musicians.'* The focus is more on asking questions than giving solutions, finding solutions and understanding learning strategies and repertoire together. Mornell also described her way of teaching as exploring together with the students. Modules at the Cork School of Music include a Reflective Portfolio Module for advanced students where the student and a teacher work together at a project or aspect where the emphasis is on the process. This is perhaps a key concept to a modern approach that differs from what we have focussed on in the past.

- Concentrating on the process and not the outcome
- Cycles of learning
- The performance as a learning environment
- Avoiding mindless, repetitive practice

These are all important aspects of deliberate practice, reflective practice, of flow theory and of sustainable performance. They are not new, but we have somehow lost track of them in our search for perfection and security.

Next Steps

A participant suggested on the feedback sheet: *'More conferences like this.'* Whilst this conference will not occur in exactly this way again, there are many ways to continue this work. The Royal Conservatorium of The Hague has expressed interest in supporting making knowledge on these subjects more accessible to teachers and students as well as in developing it – both in the expertise of its own teachers, in supporting research and masters research, and in linking up with experts in other institutions. A concrete project which some of the contributors are interested in pursuing is to develop an online resource to assimilate and distribute knowledge and ideas about all the topics discussed in the conference.

The conference demonstrated a will amongst teachers, students, experts and management to respond to the enormous challenges facing performing musicians worldwide. The Potential to Performance Team all wish and hope that the information and wisdom that were shared in this conference helps us all move forward.

Reflective practice

Dr. Gabriela Mayer

The way we think about practice influences how and what we do when engaging with different aspects of musical learning, so it is important to examine assumptions, mindset and set patterns in relation to practicing. At the core of this process is reflection, a focusing lens that can transform the ways in which we view practicing.

Rather than viewing practicing as a 'necessary evil', it is possible to encourage students to approach practice time as a time to experiment and discover, getting better in the process. Assimilating information and finding unique solutions go hand in hand. The concept of 'working hard' can gradually be substituted by the concept of 'working smart'.

Some important issues are time-management and teaching students to be more self-reliant: helping the students to help themselves by using their time effectively, making best use of their contact time with their teachers and encouraging them to approach their practice in a creative and constructive manner.

It is important to understand that mindset also plays a vital role. Students must devise strategies to deal with self criticism and negative internal dialogue and use self assessment and feedback in a constructive way. This includes being aware of psychological and physical aspects of practicing and performing and avoiding injuries. As teachers, we need to train students to devise small scale practice goals, in other words specific tasks that can be achieved in a given time frame. This time frame has to start with the daily and weekly practice which then has to be coordinated with the larger long term plan of preparing for specific performances.

Practising strategies will vary depending on whether the student is focussing on learning a piece, striving to achieve depth, speed and continuity, consolidating elements already learned, or preparing for performance. Different priorities will apply to these practice situations, and when students have a 'toolbox' of learning strategies, they can reflect and apply these in an independent and successful way.

Below are a few examples of useful questions that can form part of this 'toolbox'. Every student is familiar with at least some of these concepts, but the discussion and reflection around the learning techniques themselves is often overshadowed by the discussion on how to play a particular piece in the repertoire. Focusing on 'learning to learn' is important because the student can then take a greater responsibility for their own development.

What are your expectations when you practice?

When facing challenges, stop and analyse what is at the root of the problem first. Articulate what needs to be done and search for practical solutions, starting from the building blocks that are easy to understand and execute. Students should be reminded to organise their learning in shorter and more intense practice sessions as opposed to a prolonged practice session without clear goals. The use of repetition should be monitored by the students themselves, and used in conjunction with reflection, to become planned and exploratory variation. It is important to articulate clearly what needs to change before repeating. Mental practice should be incorporated from the learning stages to define musical intention and inform consolidation of desired small scale outcomes. This approach is more intense, but leads to more effective results, making practice less tedious and more constructive.

Who is in charge?

It is never superfluous to discuss the role of the mental direction in effective practice, as many students fall in the trap of practising with their fingers instead of their brain. We learn what we practise and the brain does not make a distinction between correct or incorrect material. Whatever gets the most repetitions will get absorbed. For example, if a student stumbles repeatedly in the same place, then retakes and goes on to play the correct version of a passage on the second 'try', in effect a new piece has been created, with an extra phrase incorporated. Greater observation on the part of the student should be promoted, choosing specific elements to concentrate on during each practice or each repetition. Observation can then lead to reflection and planning for effective solving of individual practice tasks. Linear practice is also often overused, and not conducive to quick learning in the early stages.

Practice games?

Practice games which facilitate purposeful repetition and active listening are a fun way to promote reflection. Identifying traps in pieces and planning varying elements ahead of starting to play is a very effective way to shift attention away from the syndrome of correcting mistakes. Mental preparation is then used to stay alert to the challenges that the piece presents and devise solutions to deal with these challenges. This encourages a more creative approach to practice and prompts self-reliance and independent thought.

Prioritise Practice Time: Practice spiral cycle

Visualising a spiral helps students focus on the following interlinking key areas during practice. The students need to learn to help themselves during their private practice time between lessons. The 'practice spiral' is an image describing an ongoing process which starts with clear intention, leading to execution, reflection, calibration and reinforcement.

Some sample questions associated with each key area are:

Intention: What would you like to achieve? Define specific task and ways to tackle it. The clearer the intention is defined, the better the practice process will be.

Execution: Practice must involve active listening. Be prepared to evaluate what you just did. What traps did you fall into and how could you be ready sooner in order to avoid them?

Reflection: Following evaluation, articulate what elements you want to consolidate and what you want to change. Allow more space between repetitions. Are you clear about you new objectives and do they represent small enough goals?
Varied Repetition: play again with new objectives
Consolidation: Once a desired execution has been reached, focused repetition forms a vital component in retention.

The practice spiral provides a basic structure for an effective practice regime.

Detective work – what is your mindset?

Self awareness is also a tool, and this should be used to observe negative running commentary that is often present in the mental background during practice. This always tends to be general and the best antidote is devising specific, objective goals that can be achieved in a given timeframe.

Varied Feedback

Feedback is available from a variety of sources. The most obvious one is always the feedback coming from the teacher, who can provide specific, constructive and expert advice. However, self-assessment is a vital element of learning, and this is a type of feedback that can often be improved. The student can learn to reflect on their performance in order to plan practice strategies and set tasks. Opportunities for supportive peer feedback should also be found, as these interractions promote increased opportunities to share experiences. Other forms of feedback include masterclasses, concerts, competitions and auditions.

Flexibility

One must give permission for flexibility within practice schedules. Allowing the student to "match the mood with the task" is effective in dealing with procrastination, as the mental and emotional well-being of the student is very influential in settling down to practice.

Hard skills / Soft skills

Some tasks require utmost precision, these are known as hard skills. Other tasks require a flexible approach, these are known as soft skills. Identify what type of task you are working on and use the right tools to achieve it. Hard skills are aimed at improving accuracy and reliability while soft skills are those associated with adaptability and inspiration.

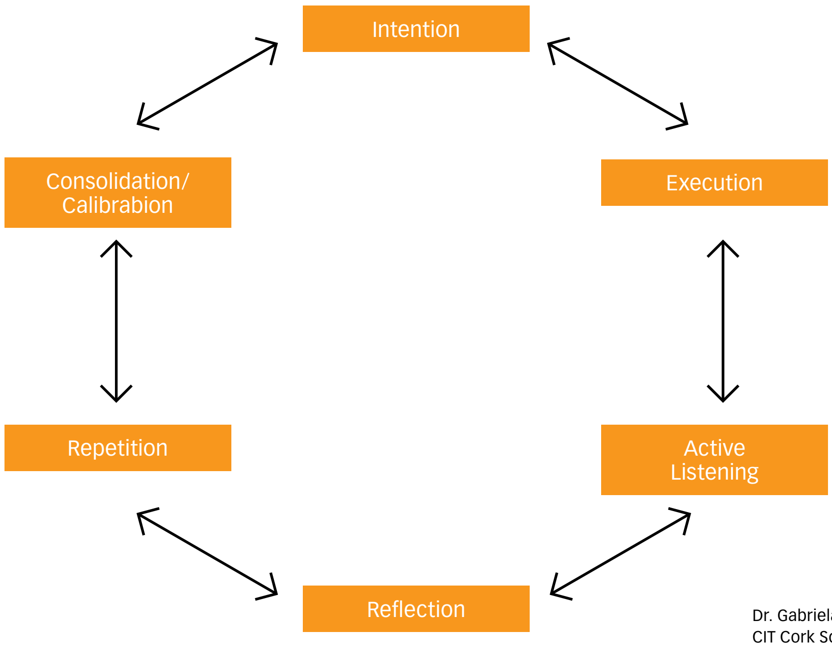
How does it feel?

Physical self-awareness on the part of the student is also important and knowing how the body feels cultivates a sense of well-being and helps to prevent over-practicing and injury. Awareness of physical need for muscles to rest and recover will lead to better planning of heavy and light days in the context of buillding stamina and working up to performance standard.

It is also important to develop personal taste, and allow autonomy and choice in the repertoire to be studied and performed as this is a long term indicator of continued involvement.

Conclusion

As practice is a lifelong activity that underpins staying active as a musician, it merits considerable consideration and reflection in order to consolidate long term effective strategies. Ultimately, the goal is to prepare students to become self reliant and creative professionals.



Dr. Gabriela Mayer,
CIT Cork School of Music

Musicians health education at the Sibelius Academy

Päivi Arjas and Erja Joukamo-Ampuja

Every year more than one hundred and twenty young, talented and hardworking musicians start their studies at the Sibelius Academy pursuing their dream to become a professional musician. They focus on their musical careers and typically have not cared about much else except their own playing. We have evaluated our students' health status during the past few years and we have noticed that musicians' health is not optimal during the challenging four to five years of study. This was the starting point for creating the Musicians' Health and Wellbeing course for the new students at the Sibelius Academy.

Musicians' Health and Wellbeing, the course for the new students at the Sibelius Academy, begins when the new students commence their studies. The Musicians' Health and Wellbeing course includes lessons about the musculoskeletal, psychological and psychosocial awareness of young musicians' bodies and the physical and mental requirements of their studies. The course provides tips for students on how to plan practising and how to start planning practising with one's own teacher. Through the course the Academy has been able to help many students who have problems with their physical playing. We have lectures about the physical and mental aspects of practising and deal with topics such as the biological limits to playing, the body recovering system, supercompensation and long-term recovery. We provide students with practical tips on mental training, how to protect their hearing, how to understand singers' specific requirements and how to recognise when it is time to see a doctor. We have workshops on basic ergonomic exercises and instrumental ergonomics. Students have the opportunity to consult a medical specialist trained to deal with musicians.

We have been able to guide many students who have problems with their physical playing. The extent of the students' problems surprised us. Almost one third of our new students reported physical problems challenging their instrumental practice before they had even started their studies at the Sibelius Academy. It would seem we have a challenge to face in spreading the word about health education to all musicians and music teachers in Finland.

Students can also receive private help from our physiotherapist (co-operation between student, physiotherapist and teacher is recommended). We also have a workshop during the spring term lasting a day which provides further individual help to students with their practice plans and mental and physical exercises.

The students give positive feedback on planning their practising. They have developed their endurance and strength in playing, timed their practising better before performances, felt less guilty in their free time, and been more aware of their physical and mental condition and limits. Students who have planned their practising have been more patient with their learning process. If they have to go to see a doctor they are more aware of themselves and the recovery chances are better.

At the Sibelius Academy we offer students an elective course called Performance and Study Coaching. It is recommended for first-year-students but is available also for students doing master or doctorate programmes. The two-part course takes two semesters, one for each part of the course. They count for 2 ECTS and 1 ECTS respectively.

During the first course a group of about ten students learn the basic facts about intuitive and acquired physical and mental responses to challenging situations and how these can give rise to positive stimulation or turn into a negative performance anxiety experience.

Numerous coping strategies are introduced. Breathing and relaxation techniques are an important starting point while concentration is broadly addressed. Musicians' self-esteem and self-confidence together with their inner voice are crucial questions for any musician and techniques for dealing with these through affirmation and other self-suggestion methods are offered as useful tools.

Mental training is an important part of the course. It has many purposes such as how to improve music reading, memorising, technical abilities, musical interpreting and communication skills and performance skills. Improving students' practising techniques is also essential.

The working methods are variable. Conversation, reflection and sharing play an important role.

The second part of the course is a practical one which awards 1 ECTS. Students work in small instrumental groups working on exercises in memorising techniques and sight-reading. Topics such as how to speak to an audience, how to behave in a concert hall and how to benefit from technical equipment are important skills. Relaxation exercises, some of the techniques that actors use to feel more comfortable on stage, and a video-taped student concert are also included in the course.

Since the autumn term 2013 a third course has been included in the programme. It is designed for students at the master level and it is part of the Sibelius Academy's Outreach programme. This course enables students to practice their skills - both musical and verbal skills - in interacting with an audience. Participants plan and practise a programme for a non-professional target group, for instance a group of people, who wouldn't normally come to a formal concert hall. The concert is implemented in pairs, videotaped and analysed afterwards. A seminar report is drawn up of the whole process.

www2.siba.fi/harjoittelu (select "in English")

How to plan your practising

Erja Joukamo-Ampuja

Musicians' Health and Wellbeing, the course for the new students at the Sibelius Academy, begins when the new students commence their studies. The Musicians' Health and Wellbeing course includes lessons about the musculoskeletal, psychological and psychosocial awareness of young musicians' bodies and the physical and mental requirements of their studies. The course provides tips for students on how to plan practising and how to start planning practising with one's own teacher. Through the course the Academy has been able to help many students who have problems with their physical playing.

After learning to plan their practising students will have developed their endurance and strength in playing, they will be able to time their practising better before performances, they will feel less guilty in their free time, more focused on practising and more aware of their physical and mental condition and limits. Students who plan their practising are more patient with their learning process as well.

What do we need to know about recovery to be able to plan practising in an effective way?

Your body is the other half of your instrument. The artistic musician and the biological musician work together. You have to remember to take care of both in your practising.
When we speak of the biological musician we are referring to all those mental and physical areas of competence – partly inherited and partly acquired – which affect how musicians' skills develop and are maintained. Many things affect your practising including your age, gender, body shape, muscular type, ergonomics, aural skills, individual playing technique etc.

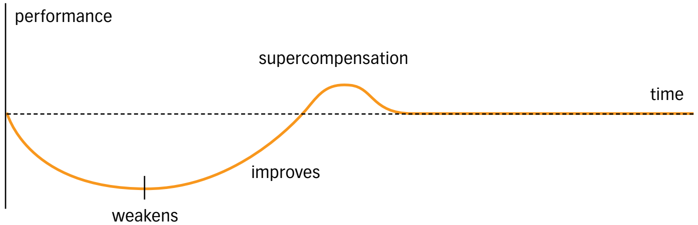
Here is some basic information about recovery and how to use that knowledge in your practising plan.

During your student years in particular it's worth dividing your practice into periods. You can plan these as periods of weeks as long as a year ahead. Practice periods (for example of a month) can often be linked to previous exercises, improved attributes and other things that you have learned. This type of long-term practice fosters development and enables your skills to improve as you wish. Healthy, varied practice that exercises the whole body also guarantees sufficient general resistance alongside that conferred by 'instrument-specific' practice. The cornerstones of practice are continuity and systematic planning.
Progressive practice gradually increases endurance and prepares you for more demanding competition and performance situations. You can't always practice harder and play more demanding pieces. It's better to draw up a varied programme and ensure that you make any necessary changes as you go along. The main aim of planning your practice is to get your body to make constant repairs and thereby achieve better form.

The advantages of planned practice

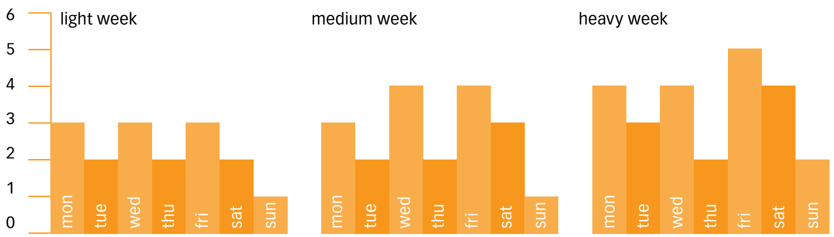
Enables optimal development
Prevents backsliding
Helps you avoid burnout and overtraining
Fosters more effective recovery
Produces better results
Generates variety which increases your enthusiasm for practice
Decreases your risk of injury

Short term body recovery



It takes your muscles about 24 hours on average to recover from a demanding practice session. On the following day, which should include a light practice session, your body will further strengthen the stressed muscles. Alternating light and heavy days will therefore ensure that your muscles will be able to replenish their energy reserves and that you will achieve a sufficient level of intensity in long, demanding exercises. Basically this means that during a heavy day you can go a little further through your programme and every second day and on a lighter day you can focus more on the details and have more short breaks during practising, practice physically lighter repertoire or just spend less time on your practising. Correct time loading and recovery will ensure that your practice has an improving effect.

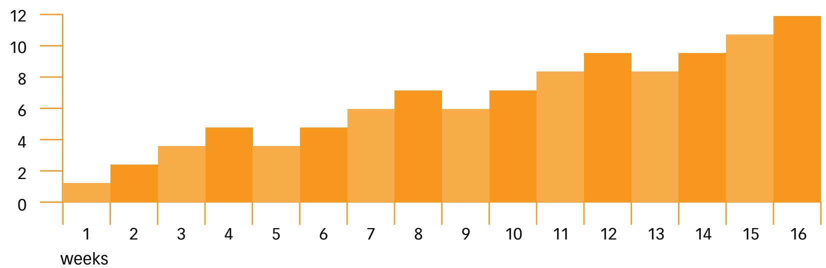
Daily rhythm/weekly rhythm



Define your playing as 0= rest day, 1 = very light day, 2 = relatively light day, 3 = standard day,
4 = relatively heavy day, 5 = very heavy day
(NOTE! These scores don't denote the number of hours you practised for.)
During a standard period, you should aim for volume-based practice and balanced loading.
The high-volume loading days will be in week 3.
Remember that 'warming down' with your instrument helps your body to recover 50% faster.

Long term recovery and planning

In all types of improving practice, every fourth week is always a recovery week! Week 4 should be lighter than week 1 in terms of loading. The tiny blood vessel (capillary) networks that transport energy to your muscles need time to renew themselves every fourth week. If you want to improve your overall muscle condition, you have to give your body time to renew and repair its capillaries; otherwise loading will eventually lead to overtraining.



You can also include your repertoire planning into your practising plan. You could play the more physically and motorically demanding repertoire later during weeks 11, 14 and 15 and play the lighter repertoire during your earlier weeks. That way you would have longer time to establish also the motorically difficult passages.

For more information go to webpage www2.siba.fi/harjoittelu (and click " in English")

The joy of flow: a flow music method for musicians

Eve Newsome

Flow or optimal experience

The concept of optimal experience or flow was derived from observation and interview-based research undertaken in the 1970's by the psychologist, Mihalyi Csikszentmihaly in his study of the phenomenology of enjoyment. A range of leisure and work activities were investigated such as rock climbing, composing, dancing, chess, basketball and surgery. Participants were asked to describe their best experiences and how it felt when they were deeply absorbed and enjoying themselves in an activity. Flow experiences were found to be accessible across a range of diverse activities that were identified as autotelic, or enjoyable for their own sake, such as sports, religion and the arts. It was found that flow activities provided clear, non-contradictory rules and opportunities for action that allowed the participant to be involved without worrying or becoming bored (Csikszentmihalyi, 1975).

From the research, Csikszentmihalyi (1990) developed a Flow theory of motivation that identified nine main elements of the flow experience (1990). These were: the merging of action and awareness; concentration on the task at hand; a challenging activity that requires high skills; the paradox of control; the loss of self-consciousness; clear goals and feedback; autotelic experience and an altered sense of time. Csikszentmihalyi's model of the flow state showed that the perception of high skills and challenges was shown to provide the psychological precondition for the flow experience. Flow feelings were activated when the challenge and skill levels were in close proximity and above the norm for the individual.

The Flow Music Method

Along with many other artistic activities, composing, playing and listening to music were classified as flow activities due to the fact that music is organised auditory information and attending to it naturally wards off feelings of boredom and anxiety (Csikszentmihalyi, 1990).
Relevant flow studies such as Csikzsentmihalyi (1975, 1990), Jackson and Eklund (2002) and Andreas Burzik (2003, 2009) were formulated into practical techniques for musicians in a Flow Music Method (FMM) designed by the author for the studio teaching of instrumental music. The FMM was founded on the concept that flow techniques can be learnt as "Ideally anyone could learn to carry inside himself the tools of enjoyment" (Csikszentmihalyi, 1990, p. 53).

Csikszentmihalyi (1990) identified that the enjoyment and satisfaction when experiencing flow was primarily possible through an awareness of one's inner state and a regulation of that state through interaction with an activity. Setting relevant goals to assist with this purpose was found to be something that could be learned and practised over time to allow more flow experiences to occur.

The Flow Music Method techniques focus on four main principles presupposed to assist in self-regulation and activation of the nine flow elements of the Csikszentmihalyi's Flow theory (1990). These are:

1. The overarching theme of enjoyment
2. Goal setting strategies
3. Body awareness and connectivity to instrument
4. Exploration and problem solving

Enjoyment is the overarching element of all flow activities so every aspect of the FMM needs to be made enjoyable for the student. The important element of challenge and skill matching is activated through clear goal setting strategies that focus attention on body awareness and sensorimotor aspects allowing for the activation of the flow elements of clear feedback; merging of action and awareness; heightened concentration; reduction of self-consciousness; paradox of control and transformation of time. Exploration and problem solving techniques encourage cognitive involvement and creativity through engagement in imaginative tasks.

Flow Music Method: Keys to Flow and the Flow Warm-up

There are three Keys to Flow that are designed by the author to enhance sensory attunement to prevent boredom and focus on relaxation to prevent anxiety and tension. They are touch sensation, quality of ease and quality of sound. These keys comprise the Flow Warm-Up, a way of connecting with the instrument before every practise or performance.

In the Flow Warm up, the student learns to improvise on easy notes and move in a harmonious way with the instrument whilst focussing on the following questions: Can I feel each and every note? Can I feel each and every movement? What can I feel? Is it an easy feeling? Is it a relaxed feeling? Am I deeply relaxed? Can I hear the overtones of my sound? Can I feel the texture of my sound? Am I enjoying/liking my sound?

After learning to use these questions to self-regulate for more positive experiences, students are asked to identify one of the Keys to Flow questions that they feel stimulates the feeling of flow most immediately for them. This question becomes their personal flow key that can be applied in practise and performance as a quick and easy way to open the flow door and enter the ecstasy of the flow zone.

Flow Music Method: Keys to Flow and repertoire practice

When musicians practise repertoire, they usually play through and discover a problem that needs solving. To do this they need to be able to identify the exact issue, understand the nature of the problem involved and apply strategies to overcome the challenge. In the Flow Music Method the students identify the issue by looking for *exactly* what feels uncomfortable or does not sound as they wish it to. Then they learn to overcome the challenge by freely improvising around it and focussing on the sensations of the Keys to Flow and harmonious body movement. To assist in this goal they apply flexible rhythm and tempo and play any notes that they feel gives them the solid physical information they are searching for. During this process they learn to trust the body feelings that tell them how fast to play and when to go on. They become aware of the level of their interest and energy levels. They ask themselves, 'What do I have to do at a *feeling* level to get the most information about this passage or section?' In this way, they use sensory experience to discover a solution and they avoid the boring mechanical repetition that can become part of a musician's practice.

During repertoire practise, there are more questions the student can apply to enhance the positive feelings that come from exploration, such as:

How about I 'play around' a bit with that passage? Do I allow flexible rhythm and tempo? How can I simplify the passage to get a feel for it? Am I just playing through or am I really exploring my piece? What is the piece or passage about? What does this passage mean to me? Do I feel the musical quality of these notes? Am I being too perfectionistic? Am I getting bored? Am I getting tired? How much doing is in my approach - too much or too little? Am I playing slowly enough? Am I enjoying myself?

Students are encouraged to include a variety of enjoyable concepts to help maintain their motivation and engagement, such as:

Imagining the sound of the music without playing it, singing the music out loud, singing the music inside, visualising and hearing themselves playing the music with all the physical movements and details of the sound picture, imagining the expressive details of the music and the exact feeling of creating them; imagining a story to go with the music; closing their eyes while playing or reducing the light source, playing the music from memory and exploring the music in any way they like.

Flow information for music teachers

Several studies of music and flow have provided information pertinent to teaching flow in music. For example, O'Neill (1999), McPherson and McKormick (2006) and Wrigley (2005) supported the proposition that training in flow activation techniques and the application of particular teaching approaches could assist flow levels in musicians. Useful practical flow techniques were detailed by Burkiz (2003) and research showed that if teachers experienced more flow, then their students reported a higher frequency of comparable experiences (Bakker, 2005).

It is recommended by the author that music teachers remain aware of the level of challenge relative to the student's developing skills. Encouraging students to develop an awareness of their inner experience allows them to match the challenge with the skills more accurately for themselves which in turn keeps them motivated and engaged. Students can learn to use their feelings like a radar to apply the techniques of self-regulation that keep the levels matching. For example, in rock climbing a climber will look for a slope that excites them in that it presents a manageable challenge that they can work out a strategy to overcome. It is the same with musicians in their choice of a new piece or study - it needs to represent a manageable or 'just-right' challenge that excites them.

The following guidelines from the FMM can be applied to encourage appropriate goal-setting when boredom and anxiety have been identified.

Find the *exact* moment when boredom sets in with a passage or there is too much focus on mechanics then take action to:

1. Check the body feeling – make sure the feeling is physically relaxed and free
2. Set a new goal by moving on to something else or doing something differently such as engaging the senses by feeling and listening
3. Use imaginative ideas and variety to stimulate a change of feeling
4. Check for tiredness and take a break if necessary

Find the *exact* moment when anxiety or frustration sets with a passage then take action to:

1. Reduce the level of challenge immediately by slowing down
2. Engage your senses by feeling and listening
3. Check the musical involvement level
4. Find a comfortable starting point in terms of body feeling; dance with your instrument
5. Check for tiredness and take a break if necessary

The teacher and student need to be aware of the impediments to flow feelings. These include too much fear, ego, ambition, trying, impatience and self-centredness as well as attentional disorders, stimulus over inclusion and looking purely for external rewards or incentives (Csikszentmihalyi, 1990).

In teaching and talent development teachers are advised to create an environment that is safe, nurturing and enjoyable to encourage flow feelings and minimise flow impediments in both themselves and their students. This can be achieved by:

1. Never stopping nurturing their own interest or taking their skills at conveying that interest to others for granted
2. Allocating attention to create safe havens for flow in learning
3. Giving attention to those conditions that enhance the experience of intrinsic rewards
4. Centering the student's attention on the challenges and inherent satisfactions of learning something new
5. Focusing on informational feedback rather than controlling feedback

6. Helping to develop autotelic personalities by training them to recognise opportunities for action, hone their skills and set reachable goals (Csikszentmihalyi, Rathunde & Whalen, 1997)

To summarise the recommended approach for teachers, a study of talented teenagers stated that, "Flow at advanced levels of mastery demands of the teacher or coach a flexible, dynamic attentional style" (Csikszentmihalyi, Rathunde & Whalen, 1997, p. 193).

Flow and music performance

The most recent empirical information about the connection between flow experience and performance levels in music has come from Wrigley's 2005 study of tertiary music students that used performance assessment measures to examine the connection between subjective states and performance levels. One of the aims was to discover whether flow experience could predict music performance quality. This was the first time that Csikszentmihalyi's flow theory (1990) had been validated in live music performance and it showed that tertiary music students experienced flow in a similar way to athletes. Implementing the Flow State Scale (Jackson, 2002) to measure experience, Wrigley found that "the more the students experienced a balance between their skills and the challenge of the performance, and the less they were self-conscious and held full concentration on their technical, and musical and interpretative skills, the better the performance outcome was" (2005, p.151).This research pointed to the possibility of improved performance levels through training in flow techniques.

Flow Music Method research

The prior research into flow provided the foundation for PhD research being conducted by the author at the Queensland Conservatorium, Griffith University (QCGU), Australia. The research aims to empirically measure any discernible changes in subjective experience and externally assessed performance that results from learning flow techniques in Eve Newsome's Flow Music Method. An educational intervention of three one hour individual Flow Music Method lessons will be given by Eve Newsome to approximately 24 QCGU classical undergraduate string and brass students.

A flow intervention group will be compared with a control group who will continue their normal major study lessons. Information about the results of the intervention will be determined by pre intervention and post intervention externally assessed performances and data concerning the subjective experience of participants. Qualitative data will also be collected from audio journal entries recorded after each practice session and an interview held after the end of the study.

To evaluate performance outcomes, the subjective experience information gathered just after the pre and post performances will be used as predictor variables against the respective outcome variables of the performances. To provide evidence for the hypothesis the findings should indicate that both groups are similar pre intervention but significantly different post intervention.

The preliminary results from the first 2013 pilot study indicate positive results from the intervention in terms of the improvement in both the positive subjective experience of the participant and the externally assessed performance outcomes.

Summary

Csikszentmihalyi's theory of flow (1990) has been found to be relevant to the domain of music. Since Csikszentmihalyi's ground breaking studies of flow in the 1970's, there have been studies from sport and other activities that have provided a useful foundation for the development of research in music. The creation of a practical Flow Music Method by the author for instrumental musicians has developed primarily from the work of Csikszentmihalyi (1975, 1990), Jackson and Eklund (2002) and Burzik (2003, 2009). The research of the effectiveness of an intervention of the Flow Music Method represents the first empirical educational of its kind in classical instrumental music. The preliminary results from the first pilot study, whilst not definitive, provide positive findings. Further findings will emerge from a larger research study by the author of the Flow Music Method at the Queensland Conservatorium, Griffith University in 2014.

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Shut up 'n play yer guitar*

Making music, practising and the brain

Wieke Karsten

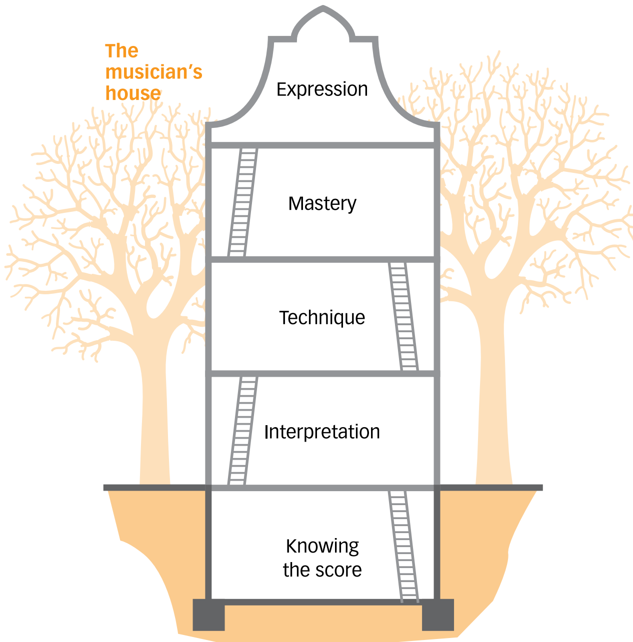
* Frank Zappa

This article presents an outline of how I teach practising and performing (classical) music based on many years of experience. That experience culminated in the method 'Making music, practising and the brain', a course I give at the Royal Conservatoire in The Hague to Bachelor and Master students. I also lead workshops and summer courses for both music teachers and performing musicians.

The article is based on questions that came up during the teaching. Formulating these questions (as any researcher will know) has guided me through the process. Insights from the field of psycho-neurology and neurology have been most helpful along with ongoing evaluation of my findings by critical students, colleagues and experts. The article describes the main principles of the course at the Royal Conservatoire and how these have evolved over the years.

As long as I can remember practising my instrument (the flute) was a mystery to me. As a student little by little I managed to spend more time on it, as I felt I was supposed to. I mainly did so because the repertoire I played became more difficult. However, I never had any idea on how long I should go on practising. Picture the timeframe: in those days (and still today) hardly anybody talked about practising other than in the sense of using a metronome and varying the rhythm.

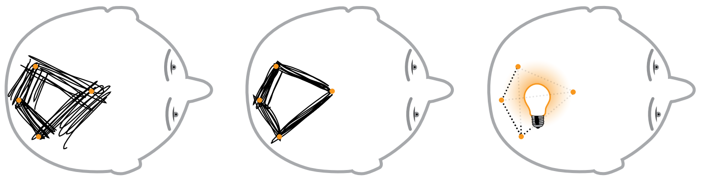
During the final of my master studies at the Royal Conservatoire, I was asked to teach the minor flute students. I realized that many of my students, and probably many other music students as well, had similar issues concerning practising. I decided to create a schedule *on what to practise* as that seemed to be an obvious starting point. After some time experimenting I created 'The Musician's House.'



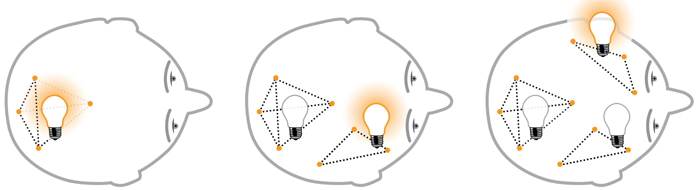
The Musician's House offers a guideline for what to practise. Practising repertoire, which is regarded as the basement, can be done by thoroughly studying the score. Then little by little students can move up to the roof. The House offers opportunities for running down and up the stairs again, as practising on the higher floors may generate new ideas for working in the basement and on the lower floors and vice versa. At that time, the content of 'mastery' remained somewhat vague, even to me, but I felt there was something more to be done than just being able to play the music well.

In the meantime, the next important question rose: *when can we say that the practising is 'done'?*
To be able to answer this question, I felt that students needed to know more about *learning processes*.

When teaching a course or workshop, basic knowledge of how learning processes take place in the brain has become the starting point. When students (and teachers) realize that this involves the development of neural connectivity (including actual tissue growth, chemical processes and the making of myelin) so as to create neural networks and when they realize how much time these processes take, their attitude towards their own learning immediately changes.

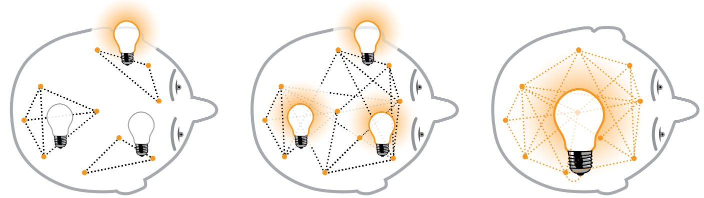

llustration of the learning process (first plural connectivity, little by little the neural pathways become more efficient).

The illustration also explains an issue that causes quite a lot of frustration among students - multitasking. Or rather not being able to multitask. During the learning process when multiple tasks are required but have not yet been internalized, the brain will have to 'choose' which network to activate. Other networks involved which are not yet 'ready' will fail to perform during multitasking causing students to make mistakes. We would be wiser to regard them however not as a 'missed-takes' but as 'not yet able-takes'. Such an attitude encourages students to be more patient and less harsh on themselves.


Multitasking (not yet possible), one light bulb is on, the others are off.

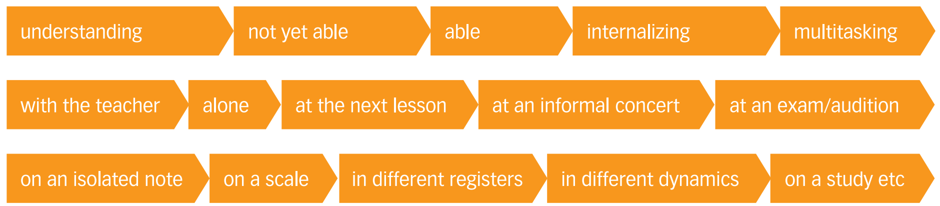
Understanding more about learning processes and internalising has been shown to be quite helpful. Multitasking can be measured by the amount of *attention* that is needed for a task. A new skill asks for 100% attention, fully internalized skills 0%. On this basis students have some idea about how to test their multitasking abilities and this makes them more aware of the level they have reached in practising so far.

Multitasking possible because of internalisation.



In the course we discuss how long these processes take, in regard to learning new skills. For that we use the following timeline, based on daily practising, 6 days a week.

Understanding à not yet able– up to 2 weeks
Understanding à internalising – up to 3 months
Understanding à multitasking – up to 1.5 years
The more complicated the multitasking for the brain, the more time is required.
The same applies to multitasking in difficult circumstances, like performing under pressure.



This is shown in the following timelines:
The next step is to make students reflect on *how* they practise. In the course I ask the students to practise in front of each other. Although this causes some tension, their behavior is still quite similar to that of their daily routine. Two things come to light. First of all, the way quite a lot of students practise is strikingly chaotic and restless, without much effect. *What on earth are they doing?* Secondly, the majority of students are unable to give any helpful feedback or advice to one another. Most students need to gain a bigger picture of the practising process and acquire tools for reflection.

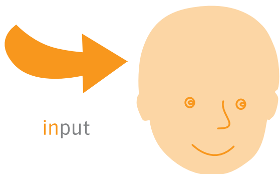
To do so I make them look at practising from a new perspective. Obviously a large part of practising is learning the score, developing an interpretation and being able to perform the music (including technical challenges) at a high level. This we can call a *learning* process: new connectivity in the brain is needed to be able to do so.

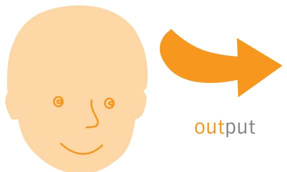
However, if that were all there was to it, performing would be: learn play à result. Although this seems right, it would mean the result is 'set'. We would play exactly the way we have practised.

Most musicians know that there is more to it than that. Performing is, next to executing the score, about being flexible on the spot. We want to respond to the other musicians (when playing chamber music), we want spontaneity, sensitivity to the acoustics of the hall, and we want to bring over emotions and to communicate with the public. To do so, we slightly change our sound projection, timing, colouring, dynamics, vibrato and articulations. In order to be flexible, we need control of our muscles (which is what making music is), directed by our imagination and use of our senses and expression.

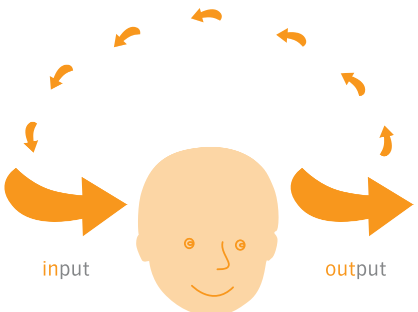
In The Musician's House we now climb up to the next floors: mastery and expression.

This means we should extend the timeline:
In the practising process we now can diverge at two levels: *learning* and *applying for stage*.





Learning I call **input**. Applying for stage I call **output**.
This is a circular process: output creates, as result of direct feedback, new input,



in the same way as input creates new output. How nice the brain is…
Making a difference between input and output proves to be extremely helpful for understanding the practising process. It also explains the chaos and restlessness that we see in many students' practising, which is caused mostly by mixing up the

input and the output. Students do so for many reasons.
First, many students try to play better (output) without investing in the learning process (input). They do so, as they expect themselves to be able to do something yesterday, which shows they have no realistic ideas of how much time a learning process takes. As the desired result might not be possible yet, this attitude towards learning causes a lot of frustration and impatience.
'Wrong – wrong – wrong – wrong – right – change subject'.
Or: *'Wrong – wrong – wrong – wrong – wrong – wrong'.* Et cetera. An endless series of non-reflective repetitive attempts, hoping things will improve.

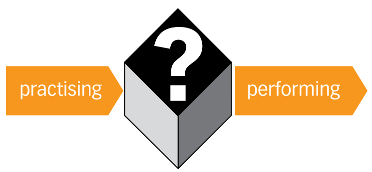
Besides no actual learning process takes place (as repetitive repetition creates almost no connectivity and the number of 'wrongs' is much higher than any 'better' version), it is alarming how this creates a feeling of negativity that is hard to break. As if students take the wrong train with no return.

Secondly, many students believe they should apply freshly learned skills immediately on all repertoire (output), hence expecting themselves to be able to multitask. *'Okay, that went well, but something else is wrong. Okay, I will improve that, but now something else is wrong. Let's do that better, but now the first thing goes wrong.' Ad infinitum*. Not surprisingly this might make students feel quite unhappy about themselves.

Interestingly enough, both ways of practising seem to be motivated by the wish not to make mistakes. 'Not yet able' makes some students feel untalented; they consider themselves 'losers' and they feel as if they continuously disappoint themselves and their environment. This fear of making mistakes strongly influences their practising. These students assume that by avoiding mistakes, by trying harder, by not doing it wrong, they should in fact be able to play well. They don't regard a mistake as missing connectivity, as something for which new neural pathways must be developed; they judge a mistake as a result of not really trying hard enough.

The same often happens when students 'play through.' Although we could regard this as clear output moments, based on the input practised so far, many students usually try to 'repair' the places they are not happy about *during* playing. This is quite distracting to the brain and through that their level decreases. Again this might make students feel disappointed. Learning to just observe the playing and remember the spots that need more work done, would be so much more effective.

On the other hand, some students keep practising the input although they could already let go of this and move on to practising for stage (output). Many times this has to do with a lack of trust in their own abilities, or because they simply have no idea *how to continue* the practising process towards performing.



This is nicely illustrated by the famous saying: practise something for the 200%, so on stage you can fall back to a 100%. While this in itself is impossible, the fatalism that it reflects speaks volumes, showing us how many of us perceive performing with its elements of uncertainty, losing control and the possibility of failure. To overcome this, we just keep practising and practising input and hoping for the best.

This is how many musicians deal with difficult passages. '*When we practise these in many, many different ways, backwards and forwards, with and without different rhythms et cetera, then we know them so well, we just have to 'push a button' and the passages will roll out of our system. If need be we could do it blindfolded. If need be, we could do so on an automatic pilot. In fact, that's what we seem to be aiming for: a solid, trustworthy automatic pilot.*'

Now we face an interesting dilemma. It is important to practise until we reach a level of internalization and multitasking. With this, we *could* play on the automatic pilot. What I found during these years is that we *should not want to aim at playing on automatic pilot*. On automatic pilot, our performance will not have the desired 'on the spot flexibility' because it is based on strong procedural motor habits which are not consciously controlled by sensory imagery or direct sensory feedback. It also means we don't need to pay attention to the task, and this offers room for thoughts that have nothing to do with music making. These thoughts can be innocent and dreamy during comfortable situations. However, on stage they will quite probably become negative. Autopilot seems attractive, since when the input is trained well, negative thinking will not even interfere with the level of playing. Nevertheless, it will possibly influence the musician's state of mind. Too many young talents play really well on stage while in the meantime their thinking is self-destructive. Playing on autopilot will never offer the enjoyment of making music in the moment itself (mastery and expression) and it will never offer the highest level of musicianship that we aim for. We need to know more about how to continue practising so we can find the best ways to train performing and offer the brain a better alternative to autopilot.

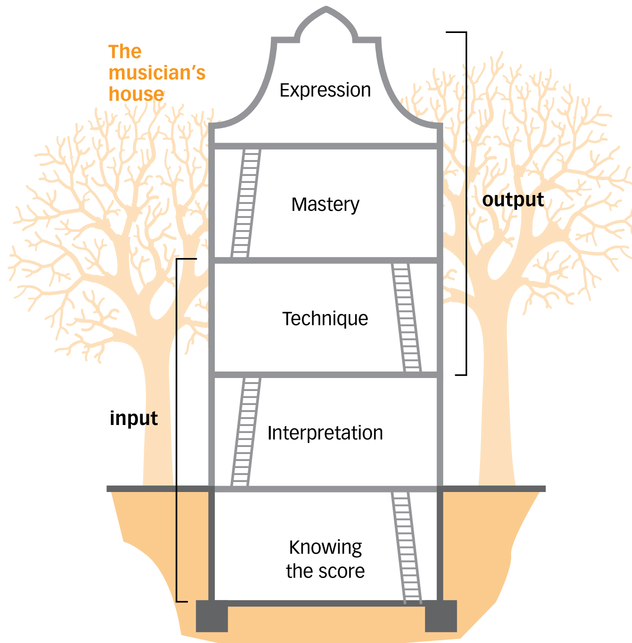
practising input → practising output → performing

But first we have to ask ourselves another question. Why has autopilot in music making become so powerful and accepted as strategy towards performing?

In practising repertoire and instrumental technique, the brain tends to take the quickest neural road possible. When children learn to play the piano, they don't necessarily connect the movement of their fingers to sound. As soon as their brain gets the 'trick', their attention fades and the pupils will start playing on their motoric autopilot. In the pedagogy of music the triangle 'reading – fingers – sound' is often mentioned, however, the neural connectivity between reading ó sound or fingers ó sound is hardly ever explicitly trained. This has two major impacts: when the motoric autopilot functions, the children will stop practising and secondly,

there is a great risk the children will lose their interest in making music, especially if practising by themselves is the only musical activity they undertake, besides the weekly music lesson.

Encouraging pupils and students to base the input on a broader neural perspective (including the triangle 'reading – fingers – sound' à active listening, body awareness, score interpretation, creativity etc.) will prevent the motoric autopilot from taking over. Then, when the practising of repertoire and skills have reached a certain level of internalizing, it is important to continue practising in a way that enhances a sensory and expressive control of the motor activity. Neural motor action plans must be developed based on musical ideas like interpretation, harmony, musical structure, characters and expression. The aim of practising output is to have these motor action plans controlled by a variety of choices. Sound images, visual images, kinaesthetic images and emotional images will become the driving force *behind* the motor actions.



In the House, we now find a large part of the content of the mastery level. In mastery, students learn to play their instrument or sing according to their musical choices. In mastery, students will train to react to other musicians, to project their sound and storytelling towards an audience, to change their playing because of the acoustics of the hall and to keep their music making flexible.

Students often realize that they are not able to do so. They do not possess a sound image that makes their muscles move, despite the many hours they have spent on solfeggio and aural skills. In the course, we discuss what this means in practical terms and how they can train these skills.

In recent findings on motor learning, the difference between motor activity without (musical) meaning and sensory and emotional based motor activity is explained by internal and external focus. Internal focus is the focus within our own body and external focus is a focus on anything outside our body. External focus can be based on a clear goal (like a dartboard) or can be based on imagery, which are representations of the outside world. Feeling my arm move backwards and forwards is an internal focus, imagining my arm moving like a swing in a children's playground, is external. When in a difficult passage I focus on my fingers, it is internal. An external focus would be to sing the melody in my mind (forward inner singing) in such a way it would make my fingers move because of this. When movements are based on this kind of sensory representations, the neural activity in the brain differs. An external focus often makes the motor activity more effective and better fit for output.

So by now I have mentioned the words *focus* and *attention*. These terms have proved to be extremely important for creating the basis for practising and performing. It took quite some time before I myself realized the importance of this. Today, focus and attention play leading roles in the course.

Finding focus and attention is not easy. Yet at the conservatoire we expect students to focus at all times. A critical question: are most musicians able to describe focus and are teachers able to convey the message? When I ask musicians to explain focus, we end up in a circular word game*: 'Focus, that's concentration…* But what do you mean by concentration? *Concentration is focusing on one thing at a time.* Okay, but then: what is focus? *Uh, it means you are in a certain state of mind.* Okay, but what do you mean by that? *That you pay attention to something, so that you are aware of it.* Okay, but what do you mean by that? *That you are able to focus'*. And so on.

From research we also learn about the importance of 'the right focus' during practising. For this the words 'deliberate practising' or 'deep practice' are used. However, this still doesn't give us any answers. So a new question has arisen: *what is 'the right focus'?*

I was happy to come across '*The Circles of Attention'* of the German sport psychologist Hans Eberspächer. In this model, Eberspächer describes on what or where a player can focus (or pay attention).

1. Me and my task
2. Direct distractions
3. It is versus should be distractions
4. Winning / losing
5. Consequences of winning / losing
6. Question of essence: what am I doing here?

The model of Eberspächer is used as a tool for training task focus. As long as athletes focus on their role in the game, they are fine. Changing the focus to anything else is a distraction, even if it is as close (in team sports) as the opponent. Instead of focusing on the opponent, it would be better to focus on the ball and where the ball should go (the goal or the team players). The higher the number of the circle, the more the focus has drifted away from the original task.

I applied this model to music making changing the names and content of the circles. I did so, as I realized that Eberspächer's circles are mainly used for winning a game. The use of the circles during training sports is generally output-based. In the musicians' case, quite a significant part of the practising process (and this is particularly true for students in the early years of their education) will be spent on input. Although the *learning process of motor skills* might be similar to sports, *learning repertoire*, which will continue lifelong, is a typical aspect of being a musician. So to make the model more applicable to both input and output, this is my translation:

1. Conscious awareness
2. Giving instructions
3. Oh no
4. The environment
5. The past and the future
6. Question of essence: what am I doing here?

1. Conscious awareness
   With conscious awareness we pay attention to what we want to learn (input) or how we want to perform (output). This awareness stimulates the activation of neural connectivity and enhances the quality of our playing. Attention or focus is primarily achieved by *using our senses consciously.* Listening to a certain sound, feeling a part of our body, looking at the conductor, are ways to explain and find focus and attention.

2. Giving instructions
   In the 2nd circle we use *thinking* in a way that helps to find the focus for practising and performing. With thinking I mean: verbalising, using words. However, thinking should be an activity that occurs as little as possible *during playing*, as thinking requires other neural activity then making music. In circle 2 we verbalize the choice of focus: *I want to listen to a certain sound, I want to feel a part of my body, I will look at the conductor.*

3. Oh no
   The difference between the thinking in circle 2 and circle 3 is judgement. In circle 2, the thinking is based on a 'to do' instruction. In circle 3, the thinking is not instructive but commenting. *'Oh no, that was wrong! It was out of tune!'* Most of the time the judgements will be negative, as many students regard making mistakes as failure. Some students wrongly assume that criticism can only be done in circle 3. However, circle 1 can be even more critical, as sensory observation (listening, watching or feeling the body) offers clear and objective information about the actual playing.

4. The environment
   In this circle students (and don't we all…) worry what passers-by might think of their practising and during the lesson they imagine what their teacher might think of their progress. On stage they worry how the audience or jury might judge their playing.

5. The past and the future
   In circle 5 students keep thinking about how they should have acted differently in the past (I should have started practising this piece much earlier…) and they worry about coming concerts, auditions and exams as well as about the future as a whole.

6. Question of essence: what am I doing here?
   Being able to classify their attention and quality of thinking turns out to be of great value to students. They now can recognize where their mind is going and take appropriate action if needed.

Alongside the model of the circles, I realized there was another kind of distraction: daily life. So I named this: Alice in Distractionland. Although routine distractions may seem innocent, their effect is always the same: distracted is distracted. Whatever causes the attention to drift away, we have to learn to return to circle 2 and 1.

So *how can one be in circle 2 and 1?*
I would like to say that outside circle 2 or 1 we cannot speak of practising. For performing circle 1 is the state of mind that must be aimed for. The attention found in circle 1 will enforce the growth of neural connectivity during learning and enhance the brain to find the best neural pathways for musical output.

I already mentioned some examples of students' practising in which this clearly wasn't the case. An important reason for losing the right focus is confusing input and output (strongly influenced by a judgemental attitude towards learning). Often students end up in circle 3+ because of a lack of preparation. Many musicians just start playing, without taking the time to get into the desired state of mind and set goals. Over the years I have found some essential requirements for preparing. First, the three-second rule. We must put our instrument down (or relax our body / arms when in a sitting position), and take time to change from instruction level (circle 2) to a chosen awareness (circle 1). Only then we should start playing.

When students find it hard to verbalize instructions, they can use de Wet van Wieke (Wieke's Law): first feel your body, then feel the pulse of the music in your whole body and then sing the music in your head. Only then start playing.

The three-second rule (or alternatively, Wieke's Law) can be the starting point for all playing, both in practising and performing. It also guarantees repetitions (as so often done in practising) to be of *retrieval* (rebuilding / reloading neural connectivity) quality.

Secondly, I make students experience the power of bodywork. When students have trouble finding circle 1, I make them do a (short) physical warm-up including jumping, running on the spot and mobility exercises. This 'call to action' brings the students back into the moment and successfully helps them to choose their focus consciously.

Next to these observations and strategies, there seem to be various practical reasons why many students end up in Distractionland or circle 3+. Some are so obvious that teachers may feel they don't need to mention them. Nevertheless, to students they can mean the world, as it explains why continuously being in circle 2 and 1 isn't possible.

- When practising input, our attention curve is limited. It could be 10 minutes or less. Students can check after a set time what the quality of their focus is, using an alarm clock (preferably not a smartphone).
- We may consider drifting away, boredom and irritation as alarm signals à take a break or change the subject.

Knowing this will give some guidelines for students in planning their practising:

- When practising input for one hour, it works best to divide the time in sessions of 10 / 15 minutes or less. After two sessions it is wise to take a short break (5 minutes) including a little bodywork.
- After 4 sessions of 10 / 15 minutes (or less) a longer break will be beneficial. Recommended: take the pause equally long as the practising time.

In the course the aim is to make students practise more consciously and thus more effectively. For this, I have them ask three questions:

1. In which circle am I?
2. Do I want to practise input or output?
3. Do I want to explore or to internalize?

Question 1 and 2 may now be clear to the reader. The third question, 'Do I want to explore or to internalize?' makes students realize they don't always have to 'set' a result. By allowing themselves to experiment, e.g. with the interpretation, the notes or instrumental technique, students show more patience and creativity in their practising. The possibility of explore and experimenting, knowing that this is fruitful to the learning process, makes practising more fun. Only after feeling that they have been fooling around enough, can they choose to practise in order to internalize. And knowing that the brain just needs one minute full focus per item per day, crowns it all…

In teaching practising, the need to talk about performing is obvious. Twenty years ago, nobody discussed the possible issues connected with performing. 'Performance anxiety' or 'choking', which are the official terms, did not exist, though many musicians suffered from this. When I started my investigation, I did not foresee that these subjects would be so connected to practising. Today, it has become a substantial component of the whole trajectory of practising from start to stage.

Performance anxiety is a three-stage rocket reaction to possible danger (which is what a performance seems like to the brain). Based on the dominance of the evolutionary oldest parts of the brain it manifests itself in physical reactions like muscular tension in the neck, shoulders and jaw, a faster heartbeat, more shallow breathing, cold sweaty hands and a dry mouth. These physical reactions can be explained as a preparation for 'freezing, fighting and fleeing', the so-called FFF-reaction. Evolutionary newer parts of the brain, like the amygdala, translate this FFF-reaction into strong emotions such as fear, anxiety and anger. And on top of that the cortex will create negative thoughts (circle 3+). The order of the three steps may depend on the situation and on the person. This rather massive defence mechanism (comparable to killing a mosquito with a hand grenade) overrules the musical brain, and thus obstructs a high level of music making and causes despair to musicians. Even today, when I lecture on this subject, students and teachers are upset that they have never been told about this before. The neurobiological explanation of stress, with such an impact on our daily life, is still largely unknown.

When I was a student, the only cure for dealing with performance anxiety was to perform as often as possible, assuming this would help to solve any problems. If it didn't, students were thought to be 'unfit for the job.' Sometimes the advice was to see a psychologist; to deal with the negative thinking and the negative emotions. Since then, more helpful tools have come to light, such as learning to neutralize the physical FFF-reaction by improving posture, physical relaxation and a more effective use of muscles, as well as training task focus; using methods like mindfulness, meditation and mental training.

Now a new question arises:
Does only the actual performing cause anxiety or does the way we practise create physical and mental tension and thus enhance performance anxiety as it becomes habitually associated with making music?

I believe the answer speaks for itself.
Students (and teachers) must be aware of the many moments when anxiety may arise during practising:

- When not practising in circle 2 and 1
- When practising without the three-seconds rule
- When mixing up output and input
- When allowing the motoric autopilot to take over

We must accept the consequences: *when practising causes anxiety, there is no circle 1. If we do not train to be in circle 1, how on earth would we be able to bring this state of mind to stage?* And: *if we do not train an alternative output to the autopilot, how would we be able to 'fulfil' our mind on stage?* The necessity of training conscious awareness, both during input and in output, including learning how to neutralize physical and mental tension, is obvious.

To make the story even more complicated, we must bear in mind a curious 'chicken-or-the-egg issue.' When students suffer from physical tension, e.g. in their hands or neck and shoulders, they experience difficulties with inner singing and interpretation. Physical tension also holds back the quality of thinking needed for circle 2. Although there is no anxious situation, the three-step-rocket seems to have been launched. Vice versa, when students find themselves in circle 3+, we can always speak of physical tension. The exact starting point of anxiety may not always be traceable. More research on this is needed.

Many aspects of *music making* literally cause tension and thus anxiety. I believe these aspects are greatly underestimated in both teaching and practising. Think of playing high notes, making big dynamic changes, playing fast and / or difficult and expressive passages. All these musical moments give rise to physical and mental tension and again we must be greatly aware of the chicken/egg issue. On this, too, more research is needed.

Recognizing anxiety during the *whole* practising process and during music making itself, is of utmost importance. In my course students learn to observe themselves when being calm, both physically and mentally. Alongside this, students have to accept the existence of the other us: anxious and stressed, circle 3+. Acceptance of this holistic evolutionary system and development of a new, neural alternative for dealing with stress, including a well-trained musical output, is the real challenge to students, teachers and conservatoires.

Illustrations: Erik Visser

Planning and performance

Eckart Altenmüller & Sabine Schneider

The article was first published as chapter 31 in the *Oxford Handbook of Music Psychology*, Oxford: Oxford University Press (2008), (pp. 332-43). The Royal Conservatoire thanks the authors and OUP for the opportunity to publish this article.

Summary

Performing music at a professional level is probably the most demanding of human accomplishments. Making music requires the integration of multimodal sensory and motor information and precise monitoring of the performance via auditory feedback. In the context of western classical music, musicians have to reproduce highly controlled movements almost perfectly with a high reliability. These specialized sensory-motor skills require extensive training periods over many years, starting in early infancy and passing through stages of increasing physical and strategic complexities. The superior skills of musicians are mirrored in plastic adaptations of the brain on different time scales.

In the first section we introduce essential general information for musical readers concerning the organisation of cortical, subcortical and cerebellar motor systems in the brain. The electrophysiological correlates of motor planning and motor expectation will be briefly mentioned, since they provide a deeper understanding of the time course of anticipation and retrieval of motor programs in music performance.

In the second section, brain processes during acquisition of skilled movements in music making will be addressed and the dynamics of neuronal networks will be demonstrated. Since these processes rely on plastic adaptations of brain networks and anatomical brain structures, the interplay of increasing precision of movements and plastic changes in the brain will be explained.

In the third section, new findings on practice strategies and performance quality will be reported. Brain imaging measures collected during mental practice or listening tasks suggest that both motor and auditory cortical areas are active during musical thought processes. Motor based brain representations are found in behavioural studies on performers' musical interpretations, transfer of learning from one musical task to another, mental practice effects, and anticipatory movements. Implications from these behavioural tasks suggest that an accurate auditory and motor representation underlies successful performance from memory.

In the fourth section, the causes of degradation of skilled movements in professional musicians will be addressed. This disorder, termed focal dystonia, is due to maladaptive brain plasticity with fusion of brain representations of adjacent digits in somatosensory brain regions. Such a fusion and blurring of receptive fields of the digits results in a loss of control, since skilled motor actions are necessarily bound to intact somatosensory feedback input. Prolonged practice and pain syndromes due to overuse can precipitate dystonia, which is developed by about 1% of professional musicians and usually ends their career.

Finally, we will end the chapter with an outlook and we will add some comments concerning the significance of results of brain research in order to improve practice habits and performance in musicians.

Introduction

There can be no doubt that making music is one of the most demanding tasks for the human central nervous system. It involves the precise execution of very fast and, in many instances, extremely complex physical movements that must be coordinated with continuous auditory feedback. Practice is required to develop these skills and carry out these complex tasks. Perhaps the most important study on practice to emerge during the past couple of decades was undertaken by Ericsson and his colleagues in 1993 with students at the Berlin Academy of Music. Ericsson et al. proposed the concept of "deliberate practice" as a means of studying goal-oriented, structured and effortful facets of practice in which motivation, resources and attention determine the amount and quality of practice undertaken. They argued that a major distinction between professional and amateur musicians (and perhaps successful versus unsuccessful learners) is the amount of deliberate practice undertaken during the many years required to develop instrumental skills to a high level (Ericsson & Lehmann 1996). They proposed that highly skilled musicians exert a great deal more effort and concentration during their practice than less skilled musicians, and are more likely to plan, image, monitor and control their playing by focusing their attention on what they are practising and how it can be improved.

Motor skills are best acquired by massed practice, involving countless repetitions whereas aural skills are typically refined through a broad variety of listening experiences. Both types of skills are not represented in isolated brain areas however, but rather depend on the multiple connections and interactions established during training within and between the different regions of the brain. The general ability of our central nervous system to adapt to changing environmental conditions and newly imposed tasks during its entire life span is referred to as *plasticity*. In music, planning, learning through experience and training are accompanied by development and changes which not only take place in the brain's neuronal networks as a result of a strengthening of neuronal connections but also in its overall gross structure. Unfortunately, it is still not completely understood how practice habits and sensory-motor maturation influence each other. With respect to brain plasticity it is known that music practice enhances myelination, grey matter growth and fibre formation of brain structures involved in the specific musical task (for a review see Münte et al. 2002).

There are two main reasons why researchers believe that these effects on brain plasticity are more pronounced in instrumental music performers than in other skilled activities. First, musical training usually starts very early, sometimes before age six when the adaptability of the central nervous system is highest, and second, musical activities are strongly linked to positive emotions, which are known to enhance plastic adaptations. We would be wise to keep in mind however, that the methodologies currently used in contemporary brain research might produce a bias. As an example, it could be argued that the results demonstrated for group investigations of classical instrumentalists are due to these musicians having a similar acculturation due to the canonical nature of their training. Classical pianists tend to study etudes of Hanon, Czerny and Chopin and the similarity of their training may produce uniform brain adaptations which in turn then dominate any individual changes. In other pursuits such as the visual arts, creative writing, architecture and composing music, individualized training may produce more diverse effects that may be masked within group statistics.

Neuroanatomy and neurophysiology of motor systems involved in planning and performance

Playing a musical instrument requires highly refined motor skills that are acquired over many years of extensive training, and that have to be stored and maintained as a result of further regular practice. Auditory feedback is needed to improve and perfect performance. Performance based music making therefore, relies primarily on a highly developed auditory-motor integration capacity, which can be compared to the phonological loop in speech production. In addition, somatosensory feedback constitutes another basis of high level performance. Here, the kinaesthetic sense, which allows for control and feedback of muscle and tendon-tension as well as joint positions which enable continuous monitoring of finger-, hand- or lip-position in the frames of body and instrument coordinates (e.g., the keyboard, the mouthpiece), is especially important. In a more general context, the motor system of music performance can be understood as a sub-specialty of the motor systems for planned and skilled voluntary limb movements.

Planned voluntary skilled limb movements involve four cortical regions in both hemispheres: the *primary motor area* (M1) located in the *precentral gyrus* directly in front of the central sulcus; the *supplementary motor area* (SMA) located anterior to the M1 of the frontal lobe and the inner (medial) side of the cortex; the *cingulate motor area* (CMA) below the SMA and above the corpus callosum on the inner (medial) side of the hemisphere; and the *premotor area* (PMA), which is located adjacent to the lateral aspect of the primary motor area (see Figure 1).

SMA, CMA and PMA can be described as *secondary motor areas*, because they are used to process movement patterns rather than simple movements. In addition to the cortical regions, the motor system includes the subcortical structures of the basal ganglia, and the cerebellum. The sensory areas are necessary in order to maintain the control of movements. Their steady kinesthetic feedback information is required for any guided motor action. The sensory areas are located in the *primary somatosensory area* (S1) behind the central sulcus in the parietal lobe. This lobe is involved in many aspects of movement processing. It is an area where information from multiple sensory regions converges. In the posterior parietal area, the body-coordinates in space are monitored and calculated and visual information is transferred into body-coordinates. As far as musicians are concerned, this area is prominently activated during tasks involving multi-sensory integration, for example during sight-reading and the playing of complex pieces of music (Haslinger et al. 2005).

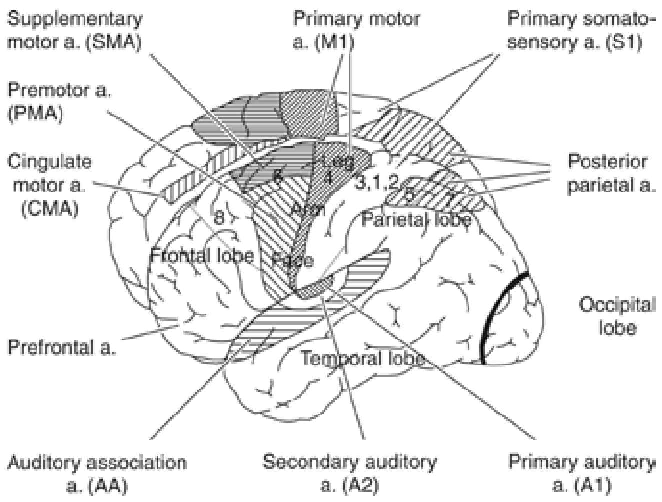


Fig. 1: Brain regions involved in sensory and motor music processing. (The abbreviation "a" stand for "area") Left hemisphere is shown in the forground (lower right); right hemisphere in the background (upper left). The numbers relate to the respective Brodmann's areas, a labelling of the cortical areas according to the fine structure of the nervous tissue.

The *primary motor area* (M1) represents the movements of body parts in a separate, but systematic order. The representation of the leg is located on the top and the inner side of the hemisphere, the arm in the upper portion, and the hand and mouth in the lower portion of M1. This representation of distinct body parts in corresponding brain regions is called *somatotopic* or *homuncular order.* Just as the *motor homunculus* is represented upside down, so too is the *sensory homunculus* on the other side of the central sulcus. The proportions of both - the motor and the sensory homunculus - are markedly distorted since they are determined by the density of motor and sensory innervations of the respective body parts. For example, control of fine movements of the tongue requires many more nerve fibres transmitting the information to this muscle as compared to the muscles in the back. Therefore, the hand, the lips and the tongue require almost two-thirds of the neurons in this area. However, as further explained below, the representation of the body parts may be modified by usage. Moreover, the primary motor area does not simply represent individual muscles: multiple muscular representations are arranged in a complex way so as to allow the execution of simple types of movements rather than the activation of a specific muscle. This is a consequence of the fact that a two-dimensional array of neurons in M1 has to code for three dimensional movements in space (Gentner & Classen 2006). Put more simply, our brain does not represent muscles but rather movements.

The *supplementary motor area* (SMA) is mainly involved in the coordination of the two hands, in the sequencing of complex movements and in the triggering of movements based on internal cues. It is particularly engaged when the execution of a sequential movement depends on internally stored and memorized information. The SMA can be subdivided into two distinct functional areas. In the anterior SMA, it would seem that the planning of complex movement patterns is processed. The posterior SMA seems to be predominantly engaged in two-handed movements and, in particular, in the synchronization of both hands during complex movement patterns.

The function of the *cingulate motor area* (CMA) is still under debate. Electrical stimulation and brain imaging studies demonstrate its involvement in movement selection in situations when movements are critical to obtain reward or punishment. This points towards close links between the cingulate gyrus and the emotion processing limbic system. From what we know therefore, it would seem that the CMA plays an important role in mediating cortical cognitive functions and limbic-emotional functions. The *premotor area* (PMA) is primarily engaged when externally stimulated behaviour is being planned and prepared. It is involved in the learning, execution and recognition of limb movements and seems to be particularly concerned with processing of visual information which is necessary for movement planning.

The *basal ganglia*, located deep inside the cerebral hemispheres, are inter-connected reciprocally via the thalamus to the motor and sensory cortices, thus constituting a loop of information flow between the cortex and the basal ganglia. They are indispensable for any kind of voluntary actions that are not highly automated. Their special role consists in the control of voluntary action by selecting appropriate motor actions and by comparing the goal and course of those actions with previous experience. In the basal ganglia, the flow of information between the cortex and the limbic emotion system, in particular the amygdala converges. It is therefore assumed that the basal ganglia process and control the emotional evaluation of motor behaviour in terms of expected rewards or punishment. Finally, the *cerebellum* contributes essentially to the timing and accuracy of fine-tuned movements.

Observing planning in the brain

During the last two decades, knowledge of brain regions involved in complex tasks such as playing a musical instrument has increased enormously. This is mainly due to the development of novel technologies that allow non-invasive assessment of the intact brains' function. A pioneering step was the observation of movement related brain potentials reflecting planning and movement preparation in the brain. These brain potentials can be extracted from the ongoing electrical activity of neuronal populations in the cerebral cortex using electroencephalography (EEG). The most prominent activation is the so callled Bereitschaftspotential (see Figure 2).

The Bereitschaftspotential (BP) is a ramp like going brain activation which precedes any self-paced voluntary motor activity, starting 2000 to 1000 ms prior to movement onset. There is still some debate on the structures in the brain generating the BP. It seems that the first part of the ramp like shift is produced in the SMA, reflecting the planning of a movement. The subsequent part of the shift is probably generated in the primary motor areas, reflecting the activation of motor neurons directly linked to muscles via the spinal cord (for a concise review see Altenmüller et al. 2004).

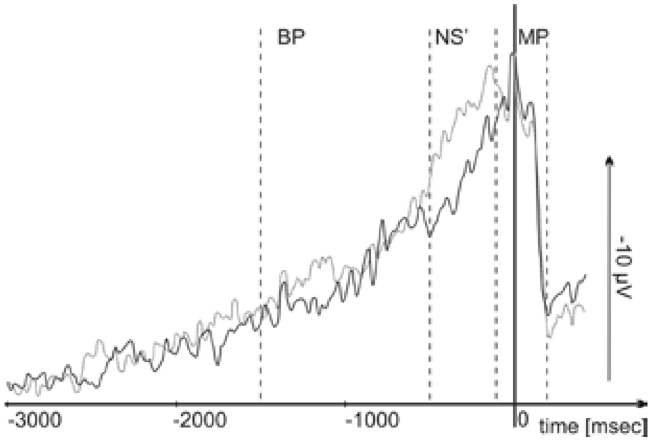


Fig. 2: Typical Bereitschaftspotential (BP) in healthy pianists and in pianists suffering from focal dystonia (dotted line) prior to scale playing (Time 0). Brain activation starts about 3 seconds prior to movement onset reflecting planning and preparation. The proper BP starts 1.5 prior to movement onset and is generated in the supplementary motor cortex. The negative slope (NS') 500 ms prior to movement onset is generated in the anterior part of the primary motor cortex. The motor potential (MP) finally corresponds to activation of the motor neurons in the pyramidal tract. After movement onset, brain activation is reset, yielding a sudden positive shift in brain activation. Note that pianists suffering from pianists' dystonia have larger amplitudes especially in the NS' component of the Bereitschaftspotential (modified from Peschel & Altenmüller 2004).

Traditionally, the BP was related to the intentional decision processes of willed action. In intriguing experiments Benjamin Libet et al. (1983) demonstrated that the BP starts about 350 ms prior to conscious awareness of the intention to act. When the subjects "vetoed" their decision to act, the BP, which had normally developed prior to this "veto", collapsed and no movement occurred. Libet (1985) concluded that voluntary acts can be initiated by unconscious cerebral processes before conscious intention appears but that conscious control over the actual motor performance of the acts remain possible. This experimental design has had a long and often controversial history. After all, it has remained unclear whether the urge to act, and the action itself, represent actual differences in brain states (Eagleman 2004).

EEG measures such as the BP-recordings have an excellent temporal resolution reflecting the electrical activity of neurons in the range of milliseconds. Therefore, these methods are suitable to investigate the rapid neuronal interactions which constitute the basis of motor planning and performance.
Other imaging tools such as positron emission tomography (PET), and functional Magnetic Resonance Imaging (fMRI) allow the functional assessment and the precise localization of active brain regions. However, these methods have the disadvantage of a relatively poor time resolution, allowing the monitoring of neuronal activation during planning and performance in the range of seconds, but not of milliseconds. Additionally, new imaging techniques, derived from the Magnetic Resonance Imaging (MRI)-Technology, precisely demonstrate minute changes in brain structure. Voxel-Based Morphometry (VBM) for example, provides detailed information of the thickness of the grey matter in the layers of neurons in the cerebral cortex. Using this technique longitudinal follow up-studies have demonstrated changes in grey matter volume in the range of cubic millimeters as a result of musical training

(Gaser & Schlaug 2003). Diffusion Tensor Imaging (DTI) on the other hand is a way to assess direction and volume of fibre tracts in the white matter of the brain. In pianists this method has shown changes in myelination of the callosal body, connecting the two brain hemispheres (Bengtsson et al. 2005).

Learning to plan: the acquisition of fine motor skills

Our knowledge concerning the regions and mechanisms of the brain involved in sensory-motor learning is still incomplete. Overall, musicians appear to process new incoming stimuli more effectively compared to non-musicians. According to newly emerging evidence (for a review see Halsband & Lange 2006) all structures involved in motor control participate in the acquisition of new sensory-motor skills. The cerebellum is involved in the selection, the sequence and the timing of movements and the basal ganglia play a crucial role in procedural learning and automation of movements.

It has been known for some time that the activity in the SMA and in the premotor area of the brain are enhanced as a result of increasing complexity of finger movement sequences (Roland et al. 1980). Using fMRI, Karni and colleagues (1995) investigated adult subjects learning of complex finger sequences which are similar to those necessary for piano playing. After 30 minutes of practice the representation of the fingers in the primary motor cortex increased. However, without further training, this effect diminished after one week with the hand representation returning to its previous size. In contrast, continuous practice resulted in a stable enlargement of the hand area in the primary motor cortex. This effect was specific for the daily trained sequence of complex finger-movements, and did not occur when the subjects improvised complex finger movements which were not subsequently repeated. Parallel to the enlargement of the hand area in the primary motor cortex, the size of the cerebellar hand representation diminished, suggesting that the cerebellum plays an important role only in the initial phase of motor learning.

The above mentioned study does not take into account one special quality of musicianship, namely the strong coupling of sensory-motor and auditory processing required for performing music. Practicing an instrument involves assembling, storing, and constantly improving complex sensory-motor programs through prolonged and repeated execution of motor patterns under the controlled monitoring of the auditory system. In a cross-sectional experiment, strong linkages between auditory and sensory-motor cortical regions as a result of many years of practice have been reported (Bangert et al. 2006). Using fMRI, professional pianists were asked to listen to simple piano tunes without moving their fingers or any other body part. Figure 3a demonstrates the increase in activation of professional pianists in comparison to non-musicians. There is an impressive activation of the motor cortex demonstrating the sub-conscious or automated auditory-motor co-activation.

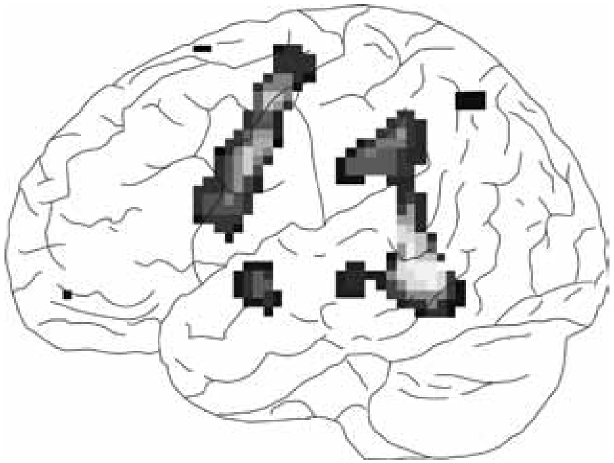
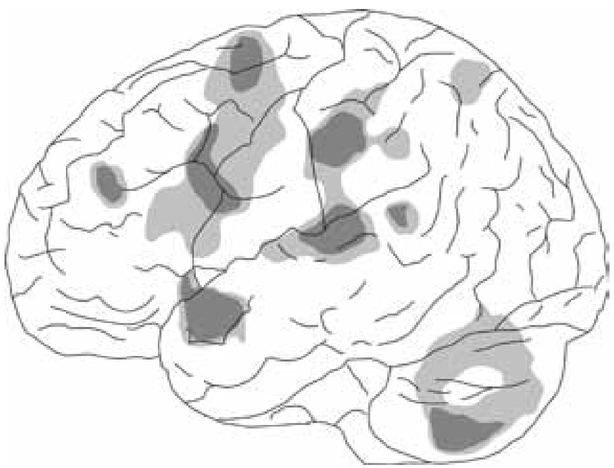


Fig. 3 (a) Additional brain activity (grey zones) of skilled pianists compared to non-pianists when listening to piano tunes without moving their fingers. The primary motor cortex of the precentral area and auditory association areas are lighting up demonstrating an unconscious co-representation of heard tunes as movement patterns (modified from Bangert et al. 2006).



(b) Additional brain activity (grey zones) of skilled pianists compared to non-pianists when observing pianist movements in a soundless video. Again, the precentral area and auditory association areas are lighting up demonstrating the mirror-system: the observed movements are unconsciously activated, albeit the subjects did not move their fingers. Furthermore the auditory areas are activated demonstrating a visual-auditory co-representation of seen movements. This effect demonstrates impressively the powerful humans imitation system and may be utilized by teachers, when demonstrating at the instrument (modified from Haslinger et al. 2005).

Furthermore, in a longitudinal study, it was possible to show that the formation of such neuronal multisensory connections needs less than six weeks of regular piano training (Bangert & Altenmüller 2003). This demonstrates how dynamically brain adaptations accompany musical learning processes.
Activation of motor co-representations can occur in trained pianists not only by listening to piano tunes, but also by observing a pianist's finger movements while watching a video. In Figure 3b the increases in brain activation of trained pianists are shown whilst they are observing video sequences of a moving hand at the piano as compared to the activation of musically naïve subjects (Haslinger et al. 2005). Besides the motor hand area in the primary motor cortex, secondary auditory cortices in the temporal lobe and the cerebellum are activated. This neuronal

network corresponds to a "mirror neuron network". As a consequence for musical practice, it follows that careful demonstration at the instrument may enhance learning. Such a teaching method based on demonstration and imitation is widely used at all levels of musical training, and would appear to be particularly effective in cases where teachers demonstrate an action or series of actions that are carefully and methodically observed by the student.

Practicing through listening and/or observation can be considered as special cases of mental training. Narrowly defined, mental training is understood as the vivid imagination of movement sequences without physically performing them. As with observation of actions, principally the same brain regions are active as if the imagined action is performed; that is, the primary motor cortex, the supplementary motor cortex and the cerebellum (Kuhtz-Buschbeck et al. 2003). In a study investigating mental training of finger movement sequences of different complexities, brain activation increased along with the degree of difficulty of the imagined motor task. Furthermore, when continuing mental practice over a period of several days, the involved brain regions showed plastic adaptations. Although these adaptations are less dramatic than if the motor tasks were practiced physically, mental training produced a clear improvement in task performance as assessed in finger tapping tests.

Plasticity of sensory motor systems: musicians' brains are different

During the past decade, brain imaging has provided important insights into the enormous capacity of the human brain to adapt to complex demands. These adaptations are referred to as brain plasticity and do not only include the connections or firing rates of neurons - the "software" of our brain - but also the "hardware", namely the fine structure of nervous tissue and even the visible gross structure of brain anatomy. Brain plasticity is best observed in complex tasks with high behavioural relevance for the individual such that they cause strong emotional and motivational activation. Plastic changes are more pronounced in situations where the task or activity is intense and the earlier in life it has been developed. Obviously, the continued activities of accomplished musicians provide in an ideal manner the prerequisites of brain plasticity. It is therefore not astonishing that the most dramatic brain plasticity effects have been demonstrated in professional musicians (for a review see Münte et al. 2002).
Our understanding of the molecular and cellular mechanisms underlying these adaptations is far from complete. Brain plasticity may occur on different time axes. For example, the efficiency and size of synapses may be modified in a time window of seconds to minutes, the growth of new synapses and dendrites may require hours to days. An increase in grey matter density, which mainly reflects an enlargement of neurons, needs at least several weeks. White matter density also increases as a consequence of musical training. This effect is primarily due to an enlargement of myelin cells: the myelin cells, wrapped around the nerve fibres (axons) are contributing essentially to the velocity of the electrical impulses travelling along the

nerve fibre tracts. Under conditions requiring rapid information transfer and high temporal precision these myelin cells grow and as a consequence nerve conduction velocity increases. Finally, brain regions involved in specific tasks may also be enlarged after long-term training due to the growth of structures supporting the nervous function, for example, in the blood vessels that are necessary for the oxygen and glucose transportation to sustain nervous function.

Comparison of the brain anatomy of skilled musicians with that of non-musicians shows that prolonged instrumental practice leads to an enlargement of the hand area in the motor cortex (Amunts et al. 1997) and to an increase in grey matter density corresponding to more and/or larger neurons in the respective area (Gaser & Schlaug 2003). These adaptations appear to be particularly prominent in all instrumentalists who have started to play prior to the age of ten and correlate positively with cumulative practice time. Furthermore, in professional musicians, the normal anatomical difference between the larger, dominant (mostly right) hand area and the smaller, non-dominant (left) hand area is less pronounced when compared to non-musicians. These results suggest that functional adaptation of the gross structure of the brain occurs during training at an early age.

Similar effects of specialization have been found with respect to the size of the corpus callosum. Professional pianists and violinists tend to have a larger anterior (front) portion of this structure, especially those who have started prior to the age of seven (Schlaug et al. 1995). Since this part of the corpus callosum contains fibres from the motor and supplementary motor areas, it seems plausible to assume that the high demands on coordination between the two hands, and the rapid exchange of information may either stimulate the nerve fibre growth – the myelination of nerve fibres that determines the velocity of nerve conduction – or prevent the physiological loss of nerve tissue during aging.

In summary, when training starts at an early age (before about seven years), these plastic adaptations of the nervous system affect brain anatomy by enlarging the brain structures that are involved in different types of musical skills. When training starts later, it modifies brain organization by re-wiring neuronal webs and involving adjacent nerve cells to contribute to the required tasks. These changes result in enlarged cortical representations of, for example, specific fingers or sounds within existing brain structures. In the following section, the behavioural correlates of the maladaptive plastic changes, leading to a loss of motor control of highly skilled movements will be focused on.

Focal dystonia: when planning goes wrong

Approximately one in 100 professional musicians suffer from a loss of voluntary control of their extensively trained, refined, and complex sensory-motor skills – a condition generally referred to as focal dystonia, violinist's cramp, or pianist's cramp. In most cases, focal dystonia is so disabling that it prematurely ends the artist's professional career (Altenmüller 2003). Subtle loss of control in fast passages, finger curling (cf. Fig. 4), lack of precision in forked fingerings in woodwind

Fig. 4: Typical patterns of dystonic posture in a pianist, a violinist, a flutist and a trombone player.

players, irregularity of trills, sticking fingers on the keys, involuntary flexion of the bowing thumb in strings, impairment of control of the embouchure in woodwind and brass players in certain registers, are the various symptoms that can mark the beginning of the disorder. At this stage, most musicians believe that the reduced precision of their movements is due to a technical problem. As a consequence, they intensify their efforts, but this often only exacerbates the problem.

Males, classical musicians of a younger age and instrumentalists such as guitarists, pianists and woodwinds are among the most commonly affected by focal dystonia. The majority of patients have solo positions and often they have a perfectionist, control-type personality. About 20% of such patients report a history of chronic pain syndromes or overuse injury. Preventing these musicians from developing chronic overuse and tendinitis will most probably prevent them from developing focal dystonia (Jabusch & Altenmüller 2006). However, once focal dystonia is established, the cure of the pain syndrome will generally not eliminate the pathological movement pattern.

Until today, the aetiology of focal hand dystonia is not completely understood, but is probably multifactorial. Without going into the details, most studies of focal dystonia reveal abnormalities in three main areas: a) reduced inhibition in the motor system at cortical, subcortical and spinal levels b) reduced sensory perception and integration; and 3) impaired sensory-motor integration. The latter changes are mainly believed to originate from dysfunctional brain plasticity. There is growing evidence for an abnormal cortical processing of sensory information as well as degraded representation of motor functions in patients with focal dystonia. A study with trained monkeys demonstrated that chronic overuse and repetitive strain injury in highly stereotyped movements can actively degrade the cortical representation of the somatosensory information that guides the fine motor hand movements in primates (Byl et al. 1996). A similar degradation of sensory feedback information and concurrent fusion of the digital representations in the somatosensory cortex was confirmed in a brain activation study conducted in musicians with focal dystonia, although these musicians had no history of chronic pain (Elbert et al. 1998). Therefore, additional factors such as a genetic predisposition and certain

susceptibility appear to play an important role in the development of focal dystonia (Schmidt et al. 2006). Interestingly, in musicians suffering from focal dystonia the BP is markedly larger as compared to healthy musicians (see Fig. 2). This "overshoot" in brain activation prior to movement execution seems to be linked to the core deficit in focal dystonia, the defective inhibition of motor output.
Unfortunately, there is no simple cure for the condition. Retraining may be successful in a minority of cases, but usually requires several years to succeed. Symptomatic treatment with temporary weakening of the cramping muscles by injecting Botulinum-toxin has proven to be helpful in other cases; however, since the injections need to be applied regularly every three to five months during the professional career, it presents no solution for young patients. Thus, the challenge is to prevent young musicians from such a disorder. Reasonable practice schedules, economic technique, prevention of overuse and pain, mental practice, avoidance of exaggerated perfectionism and psychological support with respect to self confidence are the components of such a prevention program.

Conclusions: some implications for practice

In the preceding paragraphs we have demonstrated the neurobiological foundations of planning, motor learning and practice. Here we will summarize the data in order to formulate some practical rules which might be useful for the daily work of instrumentalists.

As with all skilled human motor activities, effective planning, movement preparation and practicing are largely based on procedural knowledge. How to practice and when to stop practicing is best learned by experience. Practicing can be considered as a self-organizing process, which frequently starts with uneconomical activation of large neuronal pools in the sensory-motor brain regions. Optimizing the movement patterns occurs under continuous sensory feedback from the ears, the eyes, the muscles, tendons, joints and from the skin. The integration of this information into movement patterns is the most important step in procedural learning. It is mainly based on the formation of neuronal networks; for example, the connections between auditory and motor areas and in a stepwise reduction of cortical activity and augmentation of subcortical activity in the basal ganglia and the cerebellum.

When playing a musical instrument, the central nervous system is mainly involved in processing a huge amount of incoming information from the ears and eyes, and from the sensory organs in muscles, tendons, joints and skin. The consolidation of the networks necessary for programming movement sequences occurs mainly in the breaks after playing and during sleep. As a consequence, the more complex a task is, the shorter the practice time should be scheduled in one session and the longer the breaks should be planned. Sleep is another factor supporting procedural memory formation. Therefore, sufficient sleep should be encouraged, especially when an instrumentalist of any ability level is working hard to master new repertoire.
Generally, a practice session should be terminated when signs of fatigue appear. It is important to consider that over-practice (practice into bodily or mental fatigue) not only leads to no improvement, but to an active worsening of motor programs.

This is due to a blurring of central nervous sensory-motor representations, when muscular fatigue appears. Furthermore, a lack of attention causes a higher probability of uneconomical movements or production of false notes which, as a consequence, are stored in the procedural memory.

The human mirror system is a powerful tool to facilitate skill learning. Auditory and visual cues presented to students activate their sensory-motor representations and can lead directly to the formation of motor programs. This is the basis of imitation learning. On the other hand, sloppy and careless demonstrations may produce a negative effect for students, decreasing their sensory-motor programs as they adopt bad habits modelled by their teacher. Teachers should therefore demonstrate skills in a variety of ways in order to ensure that their students are able to comprehend the difference between effective and ineffective performance techniques.

We would like to conclude our chapter with a general remark: processes involved with instrumental musical training are probably the most complex of all human activities. Importantly, these are not restricted to the sensory-motor brain circuits but also involve emotion, memory and imagination. The best trained musicians with the best working sensory-motor networks will not move their listeners if imagination, colour, fantasy and emotion are not a part of their artistic expression. These qualities are often not trained solely within a practice studio, but depend on and are possible linked to experiences from daily life, to human relationships, to a rich artistic environment and to empathy and emotional depth. These factors, which profoundly influence the aesthetic quality of a music performance are at present far from being accessible to any neuroscientific research.

Acknowledgements
The authors thank Gary McPherson for his valuable comments on an earlier version of the manuscript. Both authors are generously supported by a grant of the German Research Foundation (Al 269/7-1).

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Insights about practice from the perspective of motor learning: a review

Gabriele Wulf and Adina Mornell

This article was first published in *Music Performance Research*. Vol 2 (2008), 1-25. The Royal Conservatoire thanks the authors and MPR for the opportunity to publish this article.

Introduction

While the learning of motor skills, including sport skills, has been examined in the laboratory, and countless empirical studies have been conducted to examine how factors such as feedback or the performer's attentional focus affect learning, musicians have chosen to look the other way. Instrumentalists and vocalists do not deny that virtuosic playing is a complex motor skill, but they shudder at the thought that their art can be analyzed and quantified. It is hard for them to relinquish the age-old belief that "hard science" cannot be used to fathom musical performance. Even music educators have shunned a systematic approach to teaching methods, preferring to rely on habit, instinct, and the master-student model that has been perpetuated for centuries (Richter, 2001). Indeed, music pedagogy has been consistently resistant to change, even in light of neurobiological evidence that has revolutionized scientists' understanding of learning and behaviour. Perhaps it is a question of identity: music teachers prefer to view themselves as artist-teachers rather than professional trainers. Fortunately, a new generation of musicians is developing curiosity for the work of experimental psychologists. In return, researchers in the field of motor learning are anxious to begin interdisciplinary studies, and welcome such adventurers with open arms, appreciative of participants who display prowess at some of the most complicated motor patterns humans can acquire.

This paper reviews research related to various factors, or practice conditions, that have been shown to have an impact on motor learning. Motor learning is typically defined as a *relatively permanent* change in the capability to produce motor skills (e.g., Schmidt & Lee, 2005). It is therefore important to keep in mind that certain practice conditions may have temporary or transient effects on performance (e.g., due to increased fatigue or enhanced motivation) that do not necessarily reflect more permanent, or learning, effects. Learning studies therefore typically consist of two phases: a practice phase in which participants practise under different experimental conditions, and delayed retention or transfer tests that are performed under common conditions for all participants. Those tests allow a cleaner assessment of what was learned, uncontaminated by the temporary influences associated with the experimental manipulations.

The learning variables we review in this paper include augmented feedback, the practice order of different tasks (blocked versus random practice), observational practice, the performer's focus of attention, and self-controlled practice. For each of these variables, we review experimental findings and address the implications of this research for musicians and music teachers. We hope that this review will stimulate further research in the field of instrumental pedagogy. It is our contention that such investigations would shed light on some of the unsolved questions posed by the evidence discussed in the following. Once a comprehensive understanding of music learning is applied to teaching methods, a tangible "science of practice" will emerge to replace the myths that surround the acquisition of musical skills.

Feedback

The typical scenario in music lessons is that of individual instruction, dominated by the teacher's critique of the student's performance through use of verbal feedback. Recent criticism of this model has arisen within the field of music education (some alternatives can be found in Ernst, 1991). Aside from the psychological and emotional problems associated with error correction – feedback may be perceived as negative, and the focus is on the judgment of others instead of one's own assessment, just to name two examples – instructor-provided feedback may interfere with the student's ability to process his or her own intrinsic feedback.

Research related to the effects of augmented feedback – that is, feedback that is given in addition to the individual's own intrinsic feedback – has a long history (for reviews, see Salmoni, Schmidt, & Walter, 1984; Schmidt, 1991; Swinnen, 1996; Wulf & Shea, 2004). The results of early feedback studies led researchers to believe that learning did not occur without feedback, and practice without feedback was thought to weaken the representation of movement in memory (e.g., Bilodeau & Bilodeau, 1958). Learning was assumed to be optimized when feedback was provided frequently and immediately (Adams, 1971; Schmidt, 1975; Thorndike, 1927). However, many of the early studies inferred learning from performance during practice and did not include retention or transfer tests (Salmoni et al., 1984). Those tests are now standard in feedback studies, and the findings of those studies have largely refuted earlier assumptions regarding the role of feedback.

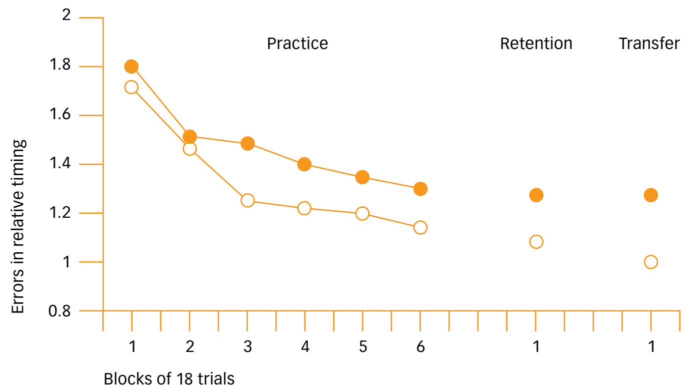
In this section, we review newer findings related to the influence the *frequency* and *timing* of feedback have on learning. (Effects of the attentional focus induced by feedback and feedback controlled by the learner are reviewed in the sections on attentional focus and self-controlled practice, respectively.)

Experimental Findings

Feedback frequency. In the first study that examined the effects of feedback frequency on learning by using a delayed retention test, Winstein and Schmidt (1990) had participants learn to move a horizontal lever in a certain spatio-temporal pattern. Feedback, consisting of the goal pattern superimposed on the produced movement pattern, was provided after either 100% or 50% of the practice trials. The results showed that the 50% feedback group produced significantly smaller errors than the 100% group in retention. Thus, in contrast to earlier assumptions, the reduced feedback frequency actually enhanced learning. In several studies, different movement variations with the same relative-timing pattern (or rhythm), but different absolute-timing characteristics, had to be learned. In those cases, the learning of the relative-timing structure was clearly enhanced by a reduced feedback frequency, compared to 100% feedback (e.g., Lai & Shea, 1998; Wulf, Lee, & Schmidt, 1994; Wulf & Schmidt, 1989; Wulf, Schmidt, & Deubel, 1993). For example, in one study (Wulf et al., 1994) participants were asked to produce a 4-key sequence on a computer keyboard (i.e., 2-4-8-6 keys on the numeric key pad). While the overall goal movement times for three different task versions were different, the relative-timing structure of the three movement segments (between key presses) was identical (1 : 2 : 1.5) for all three task versions (200-400-300, 250-500-375, 300-600-450 milliseconds). For musicians, this is comparable to playing the same four-note rhythmic motif in three different tempos. The results indicated that learning of the relative-timing pattern was enhanced for participants who were provided feedback on 50% of the trials, as compared to those who received feedback on 100% of the trials. As can be seen in Figure 1, the 50% feedback group outperformed the 100% feedback group on both no-feedback retention (involving the 3 three practice task versions) and transfer tests (with novel absolute times: 350-700-525 milliseconds). Thus, the learning of the relative-timing structure was clearly enhanced by providing less feedback. (In contrast, learning of the absolute or overall duration does not seem to be hampered by frequent feedback.)

Figure 1. Relative-timing errors (sum of proportional errors on the 3 task segments) of groups receiving feedback on 50% or 100% of the practice trials in the study by Wulf, Lee, and Schmidt (1994).

100%
50%



Timing of feedback. Feedback is typically given after the completion of a movement. Yet, it can also be provided simultaneously with the movement ("concurrent" feedback). While it is often assumed that feedback given concurrently with the movement is effective, this is generally not the case. In fact, concurrent feedback is typically detrimental to learning, compared to feedback provided after the movement. For example, in some studies feedback, in which the task required participants to move a lever in a spatially and temporally defined pattern, the feedback consisted of the (position-time) curve produced by the lever movements being superimposed on the goal, or criterion, curve. Essentially, learners were able to observe their curve being "drawn" on the criterion curve while they were executing the movement. Even though concurrent feedback enhanced performance when it was present, clear performance decrements were seen when it was withdrawn in retention or transfer tests (e.g., Park, Shea, & Wright, 2000; Schmidt & Wulf, 1997; Vander Linden, Cauraugh, & Greene, 1993; Winstein, Pohl, Cardinale, Green, Scholtz, & Waters 1996). Thus, although feedback provided concurrently with the movement temporarily enhances performance, it has little or no long-term effect. This is frequently seen in musical instruction: as long as the teacher guides the instrumentalist through concurrent feedback (singing along, counting out loud, clapping, conducting in the student's field of vision), the student stays in rhythm. This "success" is however just a short-term performance effect, and not a sign of learning. This practice session within the lesson does not necessarily guarantee that the student will practise with this rhythmic stability, nor that he or she will achieve a more rhythmic performance at a later date.

It has also been found that giving feedback immediately after the movement is less effective for learning than delaying it for a few seconds (e.g., Swinnen, Schmidt, Nicholson, & Shapiro, 1990). This effect has been attributed to learners' spontaneously evaluating the movement – based on the processing of their intrinsic feedback – before the augmented feedback is presented. Specifically requiring learners to estimate their errors after the completion of a movement has been shown to enhance learning even further (e.g., Hogan & Yanowitz, 1978; Liu & Wrisberg, 1997; Swinnen et al., 1990).

Explanations for the Effects of Feedback Frequency and Timing
The effects of feedback frequency and timing have been interpreted in terms of the "guidance hypothesis" (e.g., Salmoni et al., 1984; Schmidt, 1991). This hypothesis received its name from the fact that feedback is assumed to guide the learner to the correct movement. But, according to this view, feedback also has negative effects. When it is provided too frequently, learners tend to become dependent on it, as they by-pass the processing of their own, intrinsic feedback. This effect is particularly pronounced when feedback is provided concurrently with the movement or immediately afterwards. As a consequence, learners fail to develop their own error-detection-and-correction mechanisms that would allow them to perform effectively when the augmented feedback is withdrawn.

Furthermore, frequent feedback during practice increases performance variability during practice, as individuals have a tendency to attempt to correct even small errors that may simply represent variability in the motor system (e.g., Schmidt, 1991). In contrast, interspersed trials without feedback prompt the learner to repeat the last trial – providing response stability that seems to be a prerequisite for the development of a stable movement representation.

It should be mentioned, however, that the effects of feedback frequency seem to depend, to a certain extent, on the complexity of the skill (see Wulf & Shea, 2002, 2004, for reviews). Whereas the learning of simple skills typically benefits from reducing feedback, there is some evidence that more frequent feedback might be required for the learning of complex skills. Frequent feedback appears to be less detrimental for the learning of complex tasks because feedback is generally not as prescriptive as it often is in many simple tasks. Thus, the likelihood of the learner becoming dependent on the augmented feedback and neglecting the processing of intrinsic feedback might be reduced in complex skill learning.

Implications for Music Pedagogy
Taking these findings into consideration, one might be able to model an effective teaching strategy that uses both reduced and delayed feedback. Certainly we can infer from the above-cited studies that students should be allowed to play through a piece without interruption. Also, the instructor's question "How do *you* think you played?" following this performance is more than mere rhetoric. It encourages the student to reflect and learn. Although it is often assumed that mistakes should be avoided at all costs, a teacher calling out corrections while the student is playing does not prevent errors. Moreover, as explained above, judging performance simultaneously, or giving feedback immediately afterwards, may actually hamper learning for a number of reasons: the processing of performance is disrupted, resulting in poorer mental representations; the student does not learn to judge his or her own performance; and movement stability necessary for motor learning is reduced. It should also be kept in mind that the performance being evaluated is only a *temporary* result and not necessarily a sign of learning. Thus, the student receives feedback that may be confusing or counterproductive to the learning process. In contrast, using feedback sparingly, and providing it only after the learner has had a chance to process his or her intrinsic feedback, could result in more effective learning.

Blocked Versus Random Practice

Thomas Edison's famous quote "genius is 1% inspiration and 99% perspiration" conjures up an image of hard work via a large number of repeated trials. Indeed, the most common method of practice for a musician involves repetition, based upon a series of work loops that is often described as Test-Operate-Test-Exit (TOTE) (Chaffin & Imreh, 2002). Following a run-though of the musical composition to be worked on, musicians select the passages that need improvement (Jørgensen, 2004). Although the practice session includes multiple tasks, in a typical practice regimen, learners practise (*operate* on) one task at a time. That is, when practice of one task is completed (successful *test*), the learner moves on to the next task (*exit*), and so forth, each task in sequence. Differences in expertise are noticeable in the way musicians behave in these operational phases. Novices tend to repeat the musical phrase in question until they have reached the point at which an error-free performance has become likely. In other words, a series of perfect repetitions of the passage are considered as the signal to exit the operational stage. Many practitioners assume that this type of 'blocked' practice enables the individual to concentrate on a given task. Supposedly this is more beneficial to learning than switching frequently between different tasks would be. In the following sections, we review studies that have compared the effectiveness of blocked practice schedules with those of random practice schedules, in which learners continuously switch between different tasks. Although counter-intuitive, these findings indicate that learning usually benefits more from random practice.

Experimental Findings
A study by Shea and Morgan (1979) provided the first demonstration of differential learning effects as a function of the practice schedule – the so-called "contextual interference" effect. Contextual interference refers to the interference that is created by different tasks practised in the same session. To assess the influence of contextual interference on learning, experimental studies typically compare two very different practice schedules, namely, random practice – where the interference between tasks is high – and blocked practice – where interference is low. In the Shea and Morgan (1979) study, participants practised three different versions of a barrier-knock-down task. On each task, three of six barriers had to be knocked down in a specific order as quickly as possible. A group that practised the tasks in a blocked order, where all trials on one task were completed before the participant moved on to the next task, showed more effective performance (i.e., faster movement times)

during practice than a group that practised the tasks in a random order. This finding is not surprising, given that repetitive practice is "easier" than continuously changing tasks. However, when learning was assessed in retention and transfer tests, the random practice group clearly outperformed the blocked group.

The learning advantages of random as compared to blocked practice have been replicated in numerous experiments. The contextual interference effect has been observed not only for typical "laboratory" tasks – such as tracking, aiming, anticipation-timing, or sequential-timing tasks – but also for sport skills, including kayak rolls, badminton serves, and tennis ground strokes (for reviews, see Brady, 1998; Magill & Hall, 1990; Wulf & Shea, 2002). Overall, the effect has proven to be a fairly robust phenomenon.

The reason that blocked practice is commonly preferred in practical settings is presumably related to the greater improvements in performance seen during practice, as compared to more demanding practice schedules in which the tasks are frequently changed. That is, instructors tend to assume that the relatively fast performance improvements typically seen with repetitive (e.g., blocked) practice, as opposed to more varied (e.g., random) practice, reflect more effective learning. Interestingly, even learners themselves over-estimate how much they learned under blocked as compared to random practice conditions (Simon & Bjork, 2001). However, as pointed out earlier, *learning* can only be assessed under identical conditions for all groups. When the learning effects of blocked versus random practice are compared in retention or transfer tests, the initial (performance) disadvantage of random practice typically manifests itself as a learning advantage.

Explanations for the Benefits of Random Versus Blocked Practice

Several hypotheses have been put forward to explain the contextual interference effect. The most prominent ones are the *elaboration* hypothesis (e.g., Shea & Morgan, 1979), and the *reconstruction* hypothesis (Lee & Magill, 1983, 1985). According to the elaboration view, random practice promotes the use of multiple and variable information-processing strategies. This, in turn, leads to more distinctive and elaborate memory representations than blocked practice. Under random practice conditions, the different tasks to be learned reside together in short-term memory and can therefore be compared (which is not possible under blocked conditions), increasing the level of distinctiveness. Also, the use of different encoding strategies presumably leads to a more elaborate memory representation than the impoverished encoding under blocked conditions. The more distinctive and elaborate representation of the skill after random practice is assumed to be responsible for the learning advantages.

According to the reconstruction hypothesis, the interference created by random practice leads to (partial) forgetting of the action plan, or motor program, between practice trials. Therefore, the motor programs have to be reconstructed repeatedly. This is not necessary under blocked practice conditions, because the action plan is already in short-term memory. According to this view, the repeated action-plan reconstructions in random practice are supposed to be responsible for the learning advantages compared to blocked practice.

Implications for Music Pedagogy

The findings reviewed in this section help explain a common mistake made by both teachers and students: confounding performance with learning. Two situations, in which immediate performance is judged, are (a) during the lesson, when the student plays correctly immediately following instruction, and (b) during practice, after several error-free repeats. In both cases, there is the illusion that learning has taken place. Yet, both teacher and student are possibly judging success that may be the sign of temporary storage of the motor skill in short-term memory and not necessarily the sign of retention in long-term memory, let alone evidence of an elaborate mental representation that will allow for variation in the context of another musical composition or the same one in a future performance situation.

To our knowledge, no studies examining the contextual interference effect have used musicians or music-related tasks. Therefore, it may be somewhat premature to generally recommend random practice schedules. Also, the tasks practised in music tend to be relatively complex, and there are indications that random practice may lose its advantage if the tasks are very demanding and/or the performer has little or no experience with the respective tasks (e.g., Alvaret & Thon, 1999; Hebert, Landin, & Solmon, 1996; Shea, Kohl, & Indermill, 1990; for a review, see Wulf & Shea, 2002). That is, for the learning of complex skills where memory and information-processing demands are high, blocked practice (for example, use of the TOTE method) may be more effective, at least early in the learning process. However, random practice is usually more effective than blocked practice when it comes to the learning of relatively simple skills, for which the memory demands are comparatively low, or when individuals are experienced and the demands of the task are functionally reduced. Furthermore, after advanced movement patterns have been mastered, random practice may be better suited to skill level maintenance increasing durability of long-term memory. When concentration wanes during too much blocked practice of an already learned passage, improvement not only stagnates, it may also go backwards and performance may start to deteriorate. It is currently believed that this occurs when muscles tire and are replaced by other, less efficient ones; an alternative explanation is that this is the result of a decrease in attentiveness during practice, leading to a decline in otherwise optimized mental representations (Altenmüller, 2006, refers to the reversal of progress achieved when too much practice is undertaken as the "Penelope Effect").

Current neurophysiological research provides a further angle of explanation. Whereas repeated patterns become so well rehearsed that their execution requires little attention and a minimum of brain activity (Restak, 2001), non-repetitive practice requires increased information processing. In addition, the retrieval of such patterns is highly context dependent, and therefore repetitive practice makes musicians vulnerable. For example, a small modification of tempo to accommodate for the acoustics of the concert hall, or a change in instrument response time due to the effect of ambient temperature on the instrument can already suffice to impede execution of the practised motor patterns. Random practice is a trade-mark of expert performers, especially common in jazz musicians (Norris, 2007). Music teachers should suggest a practice schedule that alternates between blocked and random work units.

Observational Practice

Demonstration followed by imitation is a commonly used method when it comes to motor skill learning, and the study of observational learning has been the focus of considerable research since the early 1960s. In general, observational practice has been demonstrated to be a viable method of practising motor skills. The observation of demonstrations by a model seems to be particularly effective for the learning of complex skills (see Wulf & Shea, 2002). Music summer schools and master classes usually feature a maestro showing pupils and the audience how a certain musical passage should sound through performance of the same. In these cases, the teacher is exhibiting a behaviour too complex to be described by words alone. Accomplished musicians working with higher-level students rely on a mixture of demonstration and metaphor to explain how a certain phrase is executed. This leaves the transfer of knowledge up to the students' observational skills and their personal ability to extrapolate an answer from the teacher's analogy. The latter, the "answer", is often something that cannot be named, although it is observable as a change in the student's behaviour, for example, the successful execution of the passage being taught. When this newly acquired skill can be repeated again and again, and even in later performance, we extrapolate that learning through observation has occurred.

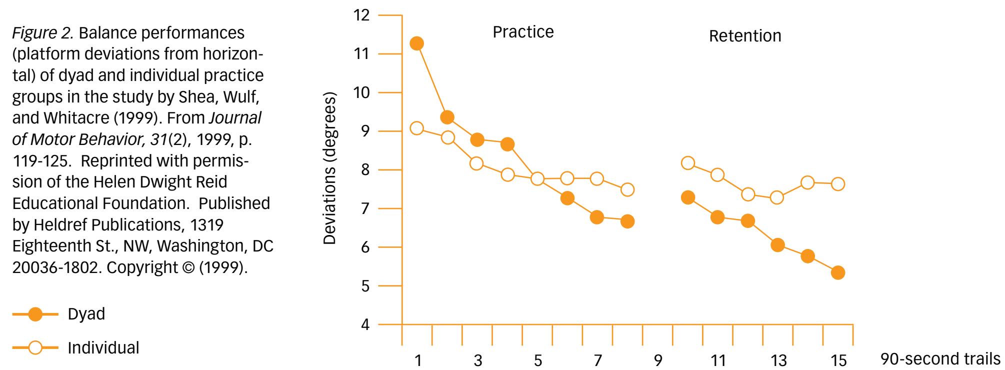
Experimental Findings

Even though observational practice is generally not considered to be as effective as physical practice, it has consistently been shown to be more effective than no practice (see McCullagh & Weiss, 2001, for a review). More importantly, combining observational and physical practice can be quite effective and even result in superior learning, compared to physical practice alone (e.g., Shea, Wright, Wulf, & Whitacre, 2000; Shea, Wulf, & Whitacre, 1999). Observational and physical practice are assumed to each provide unique opportunities for learning (Shea et al., 2000). These are discussed in more detail later. In the following sections, we review findings related to the influence of the model's skill level, practice in dyads, and the effectiveness of auditory models.

Skill level of the model. It is often assumed that the observation of an expert model is more beneficial to learning than the observation of another learner. Interestingly, however, the model's skill level appears to be relatively irrelevant (e.g., Lee & White, 1990; McCullagh & Meyer, 1997). While observing a skilled model has the advantage that the learner is provided with an image of the "ideal" movement pattern, observing another learner has been shown to offer significant benefits as well. By watching a novice model, the observer is privy to at least some of the cognitive activities associated with detecting and correcting errors that are thought to be important to learning (Lee & White, 1990). In fact, it has been shown that observational practice facilitates error recognition (Black & Wright, 2000). A precondition for learners to benefit from the observation of an unskilled model is that the model's errors are easily recognizable. Alternatively, the provision of feedback about the model's performance (e.g., from an instructor) can compensate for this drawback of learning models (Hebert & Landin, 1994).

Dyad practice. Practice in dyads (or pairs) is a training method that includes observational practice as well as other factors that could potentially contribute to learning. In dyad practice, two learners practise together, typically by alternating between physical and observational practice. While one learner practises physically, the other observes, and vice versa. Sometimes learners are also encouraged to engage in a dialogue during the rest interval between practice trials (Granados & Wulf, 2007; Shea, Wulf, & Whitacre, 1999). These periods can be used, for example, to exchange movement strategies that appear to be effective or to provide feedback to the other learner. Shea et al. (1999), for example, examined the effectiveness of dyad practice for the learning of a dynamic balance task (stabilometer), which – like many other complex motor tasks – requires rest intervals between practice trials to avoid fatigue and provide relief from the high attention/concentration demands. Their results showed that practice with a partner was more effective for learning than individual practice. Figure 2 shows the average deviations of the balance platform from the horizontal across 90-second trials for a dyad and an individual practice group. Learners who had practised with a partner performed more effectively (i.e., had smaller deviations) than individual learners on a delayed retention test that was performed individually. It should also be pointed out that dyad practice protocols have the potential to not only enhance learning, but to increase the efficiency of training (Shea, Wulf, & Whitacre, 1999). As two learners can be trained in nearly the same amount of time that it would usually take to train one person, both time and associated costs could be substantially reduced by the application of dyad practice.

Figure 2. Balance performances (platform deviations from horizontal) of dyad and individual practice groups in the study by Shea, Wulf, and Whitacre (1999). From *Journal of Motor Behavior, 31*(2), 1999, p. 119-125. Reprinted with permission of the Helen Dwight Reid Educational Foundation. Published by Heldref Publications, 1319 Eighteenth St., NW, Washington, DC 20036-1802. Copyright © (1999).



Auditory models. While there is a relatively large body of literature related to visual observation, only a few studies have examined the effects of an auditory model on learning. Anecdotal evidence suggests that providing auditory models may be rather powerful in facilitating the learning of movement sequences. For example, the Suzuki method (Suzuki, 1969) based upon the language model (Suzuki's name for the mother-tongue method is "Talent Education"), in which students are repeatedly exposed to either a parent playing a piece of music or a recorded version of it, has successfully been used to teach children how to play musical instruments (McPherson, 2007). Students are apparently able to use the memory representation, developed through the repeated exposures to the auditory model, to reproduce the musical score and make appropriate corrections, if necessary.

A few studies have experimentally examined the effects of auditory models on learning. These studies provide converging evidence that learning of movement sequences – in particular, the relative-timing structure – is enhanced by the presentation of an auditory model (e.g., Shea, Wulf, Park, & Gaunt, 2001; Lai, Shea, Bruechert, & Little, 2002). For instance, in the study by Shea et al. (2001), participants, not selected for musical ability and training, learned to produce a 1600 or 1000 ms sequence of six key presses with the same relative-timing pattern (rhythm). The absolute goal durations for the five movement segments between key presses were 300, 500, 200, 200, 400 ms for the 1600 ms task version, and 188, 312, 125, 125, 250 ms for the 1000 ms task version. In addition to visual feedback, which indicated the actual duration compared to the goal duration for each movement segment, one group was provided an auditory model before each trial. The auditory model consisted of a series of computer-tones, played in the respective (absolute and relative) goal movement times. In the first experiment, learners provided with the auditory template exhibited more effective learning of the relative-timing and absolute-timing pattern than participants not provided with the auditory template. In a second experiment, both the auditory and no-auditory template groups consisted of physical practice participants each paired with an observer during practice. The observer was privy to all instructions as well as auditory and visual information with which the physical practice participant was provided. The results again showed that the accuracy of the relative timing was enhanced by the auditory template. In fact, there was no difference between the groups that practised physically and learned through observation. However, physical practice was required to enhance absolute timing. That is, absolute timing was only improved when the auditory model was coupled with physical practice.

It is interesting to note that learners did not appear to develop a dependency on the auditory model (as is seen with concurrent feedback, for example). When the auditory model was presented prior to each practice trial, performance was enhanced almost immediately, indicating a strong guidance effect of the information. Importantly, the benefit of the auditory model carried over to the retention test where the auditory model was removed.

Explanations for the Benefits of Observational Practice

Observational practice provides the learner with an image of the goal movement. This is especially effective for the learning of complex skills, where it can provide a "picture" of how the various components of the task fit together. Like analogies, which have been shown to reduce memory demands by providing a framework in which to organize memory (e.g., Anderson & Fincham, 1994; Fery & Vom Hofe, 2000), observation may facilitate the structuring of the memories and effectively reducing the total memory demands. This phenomenon, also known as "chunking", is a necessary part of learning, encoding and storage, and later retrieval of complex movement patterns, such as those required for fluent instrumental performance of a musical composition.

Especially early in practice, where most of the cognitive resources are required to perform a new task physically, observational practice offers the learner the opportunity to engage in information-processing activities that may not be effectively carried out otherwise (Kohl & Fisicaro, 1996; Shea, Wright, Wulf, & Whitacre, 2000). That is, by observing another performer, the learner may be able to extract important information regarding the appropriate coordination pattern – which would be difficult, if not impossible, to do while attempting a new task because of the high cognitive demands (Wulf & Shea, 2002).

Practice in dyads presumably has beneficial effects on learning that go beyond those related to observation per se. Factors that might have an impact on learning in group situations are competition, social comparison, and motivation. Furthermore, goal setting (e.g., Locke & Latham, 1985; Locke, Shaw, Saari, & Latham, 1981) might be enhanced in dyad practice situations. The direct interaction with another learner might cause individuals to set higher goals than they normally would, such as outperforming the other person. Goal setting has indeed been found to benefit the performance and learning of motor skills (e.g., Boyce, 1992; Burton, 1994; Kyllo & Landers, 1995).
Auditory models apparently facilitate the development of the movement representation – without creating a dependency on the additional information. Interestingly, for relative-timing learning, auditory models can be utilized equally effectively in physical and observational practice. In contrast, absolute timing benefits of an auditory model are only seen when it is combined with physical practice. This suggests that the execution of a movement is important with regard to the planning, execution, and/or intrinsic feedback when it comes to absolute-timing learning, but not necessarily relative-timing learning (Shea et al., 2001).

Implications for Music Pedagogy

Observational practice is a part of every musician's biography. All musicians learn from listening to and watching each other. In traditional music and jazz, the apprenticeship model of learning is based upon the student's opportunities to observe and copy adult professionals. Today's classical musicians also learn to copy their teachers' demonstrations, and this is supplemented by occasional visits to concerts, which provide additional models of expertise. This form of learning dates back to the Late Middle Ages, when the novice (apprentice) was provided with an observational model (the master craftsman or craftswoman) and on-the-job training. Moving outside of these traditions, Green (2002) recently provided interview data for observational learning, demonstrating that it is the backbone of popular musicians' learning strategies. Especially during adolescence, popular musicians rely upon group rehearsals and watching each other to improve their skills. This practice is often referred to as "informal" as opposed to "formal" music education, and these musicians refer to themselves as "self-taught", although, technically speaking, they did not learn by themselves. Aside from the benefits of observational learning mentioned above, there is also an increased intrinsic motivation to practise (Kleinen & von Appen, 2007) in the peer-group setting. These are compelling arguments that music educators could and should augment their teaching practice to create additional learning situations in which apprentices can learn from *one another* for the reasons explained in this section.

An additional incentive to employ observational learning comes out of musicians' health concerns, which only recently have become the focus of attention and research. In light of the prevalence of overuse injuries among musicians (Fry, 1986), the possibility of using observational practice to replace extended hours of physical practice is of immeasurable significance. This strategy saves wear and tear on the muscles since many of the same brain regions are activated when one watches someone else do a task, as when one does it oneself; although some muscles are enervated in the process, they are not subject to the same strain as they would be in actual training. The effectiveness of this training can be increased when slower demonstration tempos are taken, or when videotapes are replayed in slow motion. The only limitation is that there must be prior motor experience with the skill being observed, otherwise it cannot be replicated mentally (Sonnenschein, 1990). It is presumed that the activation of mirror neurons is part of the explanation as to how observational learning works. On-going research hopes to explain the phenomenon better (Bangert, 2006; Schlaug & Bangert, 2007; Nirkko & Kristeva, 2006), but musicians do not have to wait until these studies are concluded; they can take immediate advantage of this training method by including it in their current repertoire of practice techniques.

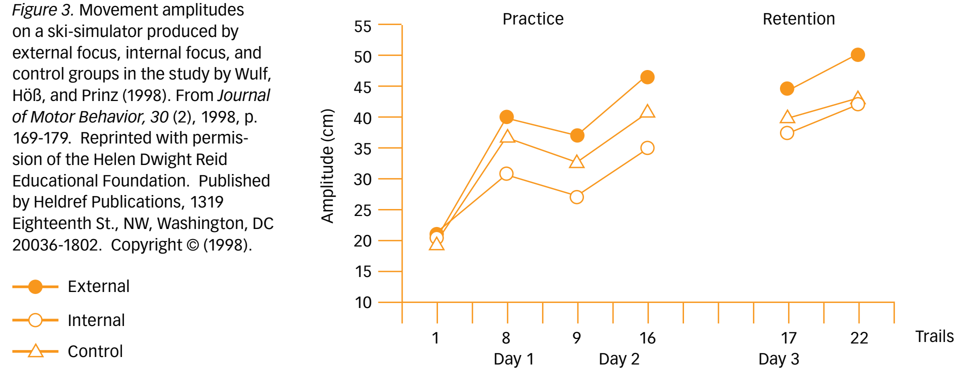
Attentional Focus

One factor that has been shown to have a significant influence on the learning and performance of motor skills is the individual's focus of attention. In most training situations, including musical practice, teachers tend to give instructions that refer to the performer's body movements. For example, a pianist will be told to hold both wrists higher when playing a scale on the black keys. A flute-player will be given instructions regarding when and how to breathe for a particular phrase. Yet, in the past few years, numerous studies have demonstrated that directing attention to one's *movements* (i.e., adopting an "internal focus") is relatively ineffective. In contrast, adopting an "external focus", or directing attention to the *effects* that one's movements have on the environment – such as the apparatus, implement, or instrument – generally results in more effective performance and learning (for a review, see Wulf, 2007a, b).

Experimental Findings

Most studies examining attentional focus effects have used relatively complex motor skills to study the effects of attentional focus instructions. For example, in the first study that demonstrated external focus advantages, a ski-simulator task was used (Wulf et al., 1998, Experiment 1). The task required participants to produce slalom-type movements with the largest possible amplitude (with a maximum of 55 cm to the left or right). The results showed that instructing performers to focus on the force they exerted on the *wheels* of the ski-simulator platform on which they were standing (external focus) – which were located directly under their feet – was more beneficial than instructing them to focus on the force they exerted with their *feet* (internal focus). As can be seen in Figure 3, the external focus group produced larger movement amplitudes on a retention test than both the internal focus and a control group without focus instructions. Thus, even though the difference in the focus of attention was rather small, it had a clearly differential effect on learning. Other studies using a variety of balance tasks have shown that learning is generally enhanced if performers are instructed to focus on the movements of the support surface (e.g., a balance board) as opposed to the movements of their feet (e.g., Totsika & Wulf, 2003; McNevin, Shea, & Wulf, 2003; for a review, see Wulf, 2007b). The benefits of directing attention to the movement effect have also been demonstrated for skills in sports such as golf (Wulf, Lauterbach, & Toole, 1999), tennis (Wulf, McNevin, Fuchs, Ritter, & Toole, 2000), volleyball and soccer (e.g., Wulf, McConnel, Gärtner, & Schwarz, 2002). In golf, for example, focusing on the swing of the *club* has been shown to result in greater accuracy of the shots than focusing on the swing of one's *arms* (Wulf et al., 1999; Wulf & Su, 2007). Thus, a simple change in the wording of instructions can have a significant effect on performance and learning.

Figure 3. Movement amplitudes on a ski-simulator produced by external focus, internal focus, and control groups in the study by Wulf, Höß, and Prinz (1998). From *Journal of Motor Behavior, 30* (2), 1998, p. 169-179. Reprinted with permission of the Helen Dwight Reid Educational Foundation. Published by Heldref Publications, 1319 Eighteenth St., NW, Washington, DC 20036-1802. Copyright © (1998).



Interestingly, in studies that included control conditions without attentional focus instructions (e.g., Landers, Wulf, Wallmann, & Guadagnoli, 2005; Wulf et al., 1998; Wulf & McNevin, 2003; Wulf, Weigelt, Poulter, & McNevin, 2003), instructions to adopt an external focus resulted in more effective learning than both internal focus and no instructions. Furthermore, there is usually no difference between instructions directed at the performer's body movement (internal focus) and no instructions. This suggests that instructions inducing an internal focus are, at best, ineffective, whereas an external focus *enhances* the learning process.

Benefits of an external focus of attention have not only been observed for novices, but also for experienced performers (Perkins-Ceccato, Passmore, & Lee, 2003; Wulf et al., 2002; Wulf & Su, 2007). For example, in a study with novice and advanced volleyball players, both groups of performers benefited equally from feedback inducing an external focus rather than an internal focus in performing a volleyball serve (Wulf, McConnel, Gärtner, & Schwarz, 2002, Experiment 1). Even though the content of the feedback information was similar for external versus internal focus groups (e.g., "Shift your weight toward the target" versus "Shift your weight from the back leg to the front leg", respectively), experienced and novice volleyball players benefited from the external focus feedback. Also, expert golfers performed pitch shots more accurately when instructed to focus on the club, as compared to their arms or no instructions (Wulf & Su, 2007, Experiment 2). These studies show that, not only at the beginning stages of learning, but even at a high level of expertise, performance can be improved by inducing an external focus.

Explanations for the Benefits of an External Focus

The advantages of an external focus have been explained with the facilitation of movement automaticity (e.g., Wulf, McNevin, & Shea, 2001). Focusing on the movement effect promotes the utilization of unconscious or automatic processes. That is, the individual takes advantage of the motor system's automatic (e.g., reflexive) control capabilities – with the result that performance and learning is enhanced. In contrast, focusing on one's own movements results in a relatively conscious type of control, which tends to constrain the motor system and disrupt automatic control processes ("constrained action hypothesis"; McNevin, Shea, & Wulf, 2003; Wulf, McNevin, & Shea, 2001; Wulf, Shea, & Park, 2001).

This notion has been supported in a variety of studies. For instance, attentional demands have been shown to be reduced (using a probe reaction-time technique) when performers adopt an external as opposed to an internal focus (Wulf, McNevin, & Shea, 2001). Furthermore, the adoption of an external focus leads to a higher frequency of movement adjustments compared to an internal focus (e.g., Wulf, McNevin, & Shea, 2001). A high frequency of adjustments is also viewed as an indication of a more automatic, reflex-type mode of control.

In addition, electromyographic (EMG) activity has been found to be reduced when participants adopt an external focus (Marchant, Greig, Scott, & Clough, 2006; Vance, Wulf, Töllner, McNevin, & Mercer, 2004; Zachry, Wulf, & Mercer, & Bezodis, 2005). This suggests movement *efficiency* is enhanced by the external focus (for a review, see Wulf & Lewthwaite, in press). Interestingly, the increased EMG activity that is seen when the performer adopts an internal focus "spreads" to muscle groups that are not directly in the performer's focus of attention (e.g., Zachry, Wulf, & Mercer, & Bezodis, 2005). That is, an internal focus appears to constrain not only the action of the body part that the individual focuses on, but also the actions of other parts of the motor system. The superfluous muscle activity presumably creates interference, or "noise", in the motor system, which hampers fine movement control and makes the outcome less reliable.

Implications for Music Pedagogy

The findings reviewed above suggest that focusing one's attention on the movement effect, rather than on the movements themselves, results in more effective (i.e., accurate, consistent) and efficient movement patterns. Even though studies related to music performance are still outstanding, the fact that external focus benefits have been found for a variety of complex motor skills, as well as for novices and experienced performers, suggests that these findings might have important implications for the training of musicians as well. Thus, not only the timing and frequency discussed in the previous section, but also the *content* of instructional feedback is important. Teachers will ideally look for verbal instructions that direct attention away from small muscle movements or body, so that automatic motor

programs are not disrupted by cognitive interference. At the same time, the externally focused music student will find and store an individual solution for a desired movement pattern implicitly – resulting in a "memory without a record" (Squire & Kandel, 1999, p. 14).

Detailed knowledge of instrumental and vocal technique is a necessary part of teacher education, since it enables the instructor to identify problems and find possible solutions. This information is then used in the selection or invention of exercises and the choice of literature. However, the student musician's awareness of individual muscle movement can be detrimental to learning. An internal focus of attention is counterproductive and might hinder the successful execution of the task, which is based upon retrieval of complex and automatic motor programs accompanied by emotion and intention to express the musical message. In fact, neuroscientists assume that mental representations of advanced performers are linked to abstract concepts of the musical work, and far removed from concrete hand and finger movements (Jäncke, 2006). Thus, when teachers give instructions, they should describe the effect to be achieved, such as "the melody line should push forward and climb towards the climax" as opposed to the specific "strike the notes harder using finger muscle and increase arm thrust towards the end of the line"; or using an image such as "the accompaniment is like a peaceful ocean of sound" rather than "pull back your left wrist to prevent the fingers from reaching the bottom of the key bed."

Sometimes computer programs are used to assist with singing training (for a review, see Hoppe, Sadakata, & Desain, 2006), and their effectiveness may also be a function of the attentional focus they induce. These programs can provide real-time visual feedback (VFB) on various aspects of performance, including pitch, timbre, shimmer, or jitter. In their review of studies that examined the usefulness of such feedback on singing performance, Hoppe et al. (2006) came to the conclusion that this type of concurrent feedback can be an effective addition to traditional singing lessons with a teacher. However, they also note that the attentional focus induced by the feedback may qualify its effectiveness: "VFB that is directed to one's own movements (e.g., the vocal tract) may be less effective than VFB on the acoustical output (e.g., real-time spectral information)" (Hoppe et al., 2006, p. 316). While this hypothesis is in line with previous findings (Shea & Wulf, 1999), it is also reasonable to assume that concurrent VFB may generally be effective because it tends to direct performers' attention to the visual outcome (i.e., externally).

Virtuosity is acquired by "doing", that is, by practising (Altenmüller, 2006), and not by being told what to do. Teachers often attempt to fix students' technical problems by using *internal* focus instructions, but these problems have been seen to solve themselves when the right *external* goal is offered. Directing one's attention away from a "difficulty" also relaxes the player; relaxation is a prerequisite for optimal learning. Also, an external focus of attention provides the appropriate mind-set for the musician that is essential for playing successfully in public. Disaster can occur when one suddenly switches from external to internal focus mid-performance, interrupting a smoothly functioning complex motor pattern that is running without conscious control. Any attempt to monitor or control individual movements, a desire driven by cognition, can be detrimental. Therefore, musicians are better off imaging the effect they want create, not trying to control exactly how they achieve the effect, and they should attempt to hear piece as a whole, not as the sum of its parts. This concentration on interpretation and music making must be rehearsed well in advance of the concert. Similarly, musicians should practise playing with a feeling of autonomy from the opinions of others. The latter is best acquired through practice that is self-motivated and self-guided, as seen in the following section.

Self-Controlled Practice

In most training situations that involve the learning of motor skills (e.g., sports, physical or occupational therapy), the instructor determines the details of the training protocol. For example, a physical therapist might prescribe the exercises he or she wants the patient to perform, the order of different exercises, and the number of sets and repetitions for each. Coaches provide feedback to athletes about correct or incorrect parts of the movement, and may give demonstrations of the goal movement pattern. Thus, instructors typically control most aspects of the training, whereas the learner assumes a relatively passive role. To a certain extent, this applies to music as well when musicians are dismissed from their lessons with an assignment book full of goals that they are supposed to tackle at home, alone. Ideally, the music teacher will spend lesson time teaching the student how to solve problems, create new tasks, and set up his/her own practice regime. Although this would benefit students at all levels, it is usually only advanced students who step out of the passive role and take responsibility for their own training sessions – despite the evidence that is the subject of this section.

The role of self-regulation, or self-control, in learning was first discussed in the literature on verbal or cognitive learning (e.g., Carver & Scheier, 1990; Paris & Winograd, 1990; Zimmerman, 1989), and there is general agreement that self-controlled learning has a beneficial effect on the learning process. In recent years, there has been increasing interest in this phenomenon in the motor learning domain as well. Accumulating evidence suggests that the effectiveness of motor skill learning can indeed be enhanced if the learner is given some control over the practice regimen. That is, compared to prescribed training protocols, giving learners a certain degree of self-control generally result in more effective learning.

Studies on self-controlled learning typically involve a "yoking" procedure, whereby each participant in a self-control group is yoked to a participant in another group. For example, if the variable to be controlled is the feedback presented after a trial, each yoked participant would receive feedback on the same trials on which her or his respective self-control counterpart had requested feedback (e.g., Trials 1, 3, 4, 7, etc.). The purpose of such a yoking procedure is to control for the amount and scheduling of feedback (or whatever factor is controlled by the learner). Because, on average, the frequency and timing of feedback are identical in the self-control and yoked groups, any group differences that emerge on retention or transfer tests

can be attributed to the fact that one group had control over the feedback schedule, while the other group did not.

In this section, we review studies that have examined the effects of self-controlled practice on motor learning. These studies have focused not only on the delivery of feedback, but also on the use of physical assistance devices, and movement demonstrations.

Experimental Findings

Feedback. A number of studies have examined the effectiveness of self-controlled feedback schedules (e.g., Chen, Hendrick, & Lidor, 2002; Chiviacowsky & Wulf, 2002; Janelle, Barba, Frehlich, Tennant, & Cauraugh, 1997; Janelle, Kim, & Singer, 1995). In one of those studies, participants practised throwing a ball at a target with the non-dominant arm (Janelle et al., 1997). One group of learners ("self-control") had the opportunity to indicate when they wanted to receive feedback regarding their movement form, or technique. If requested, the experimenter would provide feedback based on the participant's performance on the previous trials. The results showed that self-control participants demonstrated more effective learning with regard to both movement form and throwing accuracy, compared to yoked participants.

Other studies have found advantages of self-controlled feedback for the learning of sequential timing tasks (Chen, Hendrick, & Lidor, 2002; Chiviacowsky & Wulf, 2002). For example, Chiviacowsky and Wulf (2002) used a task that required participants to press four keys (2, 4, 8, and 6) on the numeric keypad of a computer keyboard in a prescribed temporal sequence. The goal movement times for each of the three movement segments (between keys) were 200, 400, and 300 milliseconds. Feedback consisted of the actual movement times, as well as the goal movement times, for each movement segment. When the production to novel goal movement times (300, 600, 450 ms) was required in a transfer test, the self-controlled feedback group again outperformed the yoked group. This finding demonstrates that the benefits of self-controlled feedback can also transfer to novel variations of the skill.

While studies on self-controlled practice have almost exclusively used adults as participants, a more recent experiment demonstrated similar benefits for children as well (Chiviacowsky, Wulf, Laroque de Medeiros, & Kaefer, 2008). In that study, 10-year old children practised tossing beanbags at a target with their non-dominant arm. The results showed that self-controlled feedback resulted in a significant learning advantage (i.e., more accurate throws) on a delayed retention test without feedback.

Assistive devices. Other studies have looked at the self-controlled use of physical assistive devices, which are often used in the learning of balance skills (Wulf, Clauss, Shea, & Whitacre, 2001; Wulf & Toole, 1999). In one study, participants practised a ski-simulator task (Wulf & Toole, 1999). The physical assistance devices used in that study were ski-poles, which generally facilitate the maintenance of balance and have been shown to enhance the learning of this task (Wulf, Shea, & Whitacre, 1998). Participants in the self-control group were allowed to choose on which trials they wanted to use the assistive devices during practice. The self-control participants showed clearly more effective learning, that is, larger movement amplitudes, than did their yoked counterparts. In a follow-up study (Wulf, Clauss, Shea, & Whitacre, 2001) it was found that self-controlled learners also demonstrated a more efficient movement technique (as indicated by the weight shift from one leg to the other). This suggests that self-control learners engage in different information-processing activities, such as a search for the optimal movement pattern, and that these activities were facilitated by their ability to choose, or not to choose, the assistive devices.

Demonstrations. One study looked at whether providing model presentations at the learners' request would enhance learning, compared to providing them without consideration for their preferences (Wulf, Raupach, & Pfeiffer, 2005). In that study, participants practised a basketball jump shot. A video of a skilled model could either be requested (self-control) or was provided at the respective times (yoked). After a seven-day retention interval, the self-control group had significantly higher form scores than the yoked group (see Figure 4). That is, despite an initial disadvantage in skill level, the self-control group showed considerably greater improvements in movement form, and demonstrated more effective learning on the retention test. Interestingly, the differential learning effects occurred despite a relatively low frequency of model presentations (5.8% of the practice trials).

Explanations for the Benefits of Self-Controlled Practice

In general, self-controlled practice conditions are assumed to enhance learning because they lead to a more active involvement of the learner in the learning process and encourage learners to take charge of their own learning process. This, in turn, might make learning more motivating and increase the effort invested in practice (Ferrari, 1996; McCombs, 1989; Watkins, 1984).

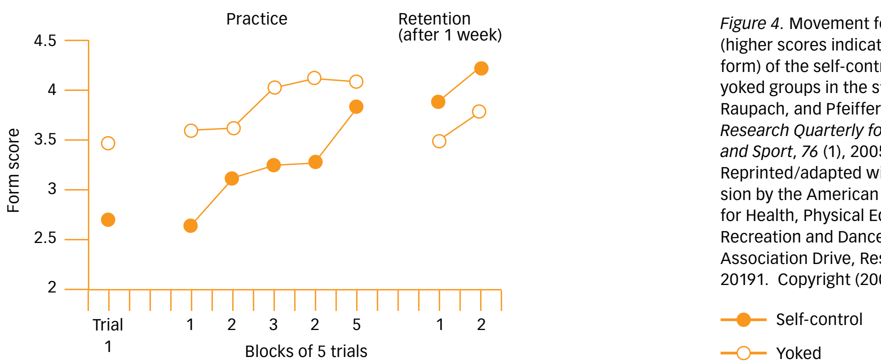


Figure 4. Movement form scores (higher scores indicate better form) of the self-control and yoked groups in the study by Wulf, Raupach, and Pfeiffer (2005). From *Research Quarterly for Exercise and Sport*, *76* (1), 2005, p. 107-111. Reprinted/adapted with permission by the American Alliance for Health, Physical Education, Recreation and Dance, 1900 Association Drive, Reston, VA 20191. Copyright (2005).

In addition, self-controlled practice conditions seem to be more in line with the learner's needs or preferences, compared to externally controlled conditions – which might also enhance learning (Chiviacowsky & Wulf, 2002). For example, with regard to the use of assistive devices, self-controlled practice might result in more effective learning, because it allows learners to explore movement strategies to a greater extent than practice without self-control does (Wulf & Toole, 1999). That is, the learner might try out a certain strategy with the assistive devices on one

trial, and then without the devices on the next trial. With respect to feedback, questionnaire results (Chiviacowsky & Wulf, 2002) revealed that self-control learners (as well as yoked learners) preferred to receive feedback after a trial that they perceived as 'good'. In fact, self-control participants asked for feedback predominantly after relatively successful trials. Yoked learners, of course, did not have this opportunity. Finally, learners might extract more, or more relevant, information from model presentations when they have the opportunity to request them. For instance, self-control learners might pay particular attention to aspects of the movement they are uncertain about – either to identify errors, or to obtain confirmation that their movement is correct. In contrast, learners without the opportunity to request demonstrations might be less inclined to engage in such information-processing activities due to the unpredictability of the model presentations.

Overall, the picture that emerges from these studies is that the benefits of self-controlled feedback are due primarily to a more active involvement of the learner in the learning process, with a concomitant increase in motivation. This, in turn, seems to lead to deeper information processing and ultimately to enhanced learning. In short, a complex motor skill such as instrumental virtuosity is not a fixed ability, but "flex-ability", and the more variations explored during practice, the better equipped the instrumentalist/vocalist will be to face the challenges of musical performance.

Implications for Music Pedagogy

While it may appear to be challenging to organise practice sessions for musicians similar to the above-described motor learning settings that often exist only in the lab, this does not mean that these results bear no significance to music learning. On the contrary, music educators can take example from these experiments and modify routines that have dominated lessons for decades. It is not only beneficial for learning when students actively request feedback, it also makes the lesson more interesting for both parties.

Some studios have a variety of assisted devices, from Music Minus One and Band-in-a-Box recordings, to midi-compatible instruments, mirrors and other training equipment. Since the value of student initiative cannot be underestimated, teachers should allow students to determine when they work with such devices. As for self-determination of the timing of demonstrations, ever more music DVDs of both contemporary and historic performances are being released and are available in school libraries for viewing or loan, or for purchase at reasonable prices. These provide students with unprecedented access to international artists across several generations; they can both hear and watch a variety of professionals performing advanced pieces of music. For works at lower levels, teachers can use video or digital cameras (or even cell phones) to make short movies, thus enabling beginners to observe a skilled model perform the piece they are working on whenever desired. In this way, modern technology can aid teaching and provide students with more autonomy in the learning process.

Students do not automatically take responsibility for what they do outside the lesson. Being on their own does not mean that they invest effort or creative energy in their practice. Following the adage "practice makes perfect", they repeat their pieces over and over again. Repetition leads to boredom and loss of attention. These are exactly those factors that prohibit even a willing student from developing good work habits and being innovative when it comes to problem solving. Often even the so-called "good students" follow the assignment book to the letter, without meaningful work phases or flexible practice strategies. Some students ignore the teacher's advice and just play their pieces from start to finish multiple times until their practice time is up. Others 'play' in the sense of play around, which can be a good motivational tool, but does not contribute much to progress in motor learning. Motor learning studies on the effectiveness of self-controlled learning suggest that music pedagogy research in the near future should address the problem described here: teachers need strategies with which to teach students how to work effectively on their own.

Summary and Conclusions

The motor learning research presented above should provide inspiration to the musician and music educator. These experimental findings present evidence of practice and instructional effects that suggest new directions in training and pedagogy. Even though experimental studies examining the learning of musical skills are still lacking, it is not too soon to take the preceding discussion of evidence regarding feedback, blocked vs. random practice order, observational practice, attentional focus, and self-controlled practice and look at its ramifications for music.

Several times in this paper we have argued that there is a big difference between performance and learning. The following scene illustrates the importance of this distinction: In answer to the teacher's question "Last week we practised this together you got it right, how could it get worse?" the student counters, "I played it better at home." The teacher is convinced that the student has not practised; the student is frustrated. Both are caught in a tango in which the traditional roles of formal, classical music training have both of them locked into steps that repeat and repeat. Both partners have mistaken temporary performance effects for long-term learning. The student believed that blocks of error-free repetition in the context of the home environment were evidence of more permanent learning. And the teacher, who was pleased with the student's run-throughs in the lesson, thought that these results were sufficient to ensure that the correct motor pattern could be repeated at home. The student was assured by the teacher's positive feedback during the lesson.

The evidence provided here suggests answers to an issue raised at the start of this paper: the optimal practice strategy. Researchers studying expertise have also affirmed many of the factors discussed here. They have identified and defined "deliberate practice" as the common denominator among experts, regardless of field of work (e.g., Ericsson, 2002; Ericsson & Charness, 1994; Ericsson, Krampe, & Tesch-Römer, 1993; Lehmann, 1997). This type of practice involves concentration, building blocks of learning, guidance through constructive feedback, and emphasis on long-term goals instead of short-term performance.

All of the issues raised here, the value of professional feedback, varied practice schedules, observational practice, externally directed focus of attention, and self-controlled learning are applicable to musicians. At the core of any teacher or trainer's work is the guidance of students through high quality feedback. Teaching professionals should be prompted by the evidence presented here to review the timing and quantity of such feedback, perhaps by video taping and critically evaluating their lessons. The same flexibility is required in reviewing rehearsal habits. It will not be easy to dispense with preconceptions about the value of repetition perpetuated over centuries and experiment with variable practice, but the aforementioned studies should offer motivation for such a step. We have also seen that observational learning provides advantages through facilitation of information processing; by providing additional sources of motivation, especially through peers; creating less dependency upon the presence of a teacher; and a reduction of the danger of the "overuse" syndrome. All of these reasons may help improve the reputation of group lessons, which are largely seen as an economical rather than a pedagogical necessity.

The goal of top musical training, as in most other fields, is the ability to work independently, that is, to exhibit self-control and self-determination. The achievement of this goal is likely to be hampered by frequent feedback, for example. It inhibits the processing of intrinsic feedback and creates dependency on the teacher, and it prevents flexible practice necessary to establish the skill in a multi-faceted representation that can be modified and is not dependent upon the context in which the performance takes place. The sooner that musicians-in-training learn to be their own best critics, the less likely they are to condition themselves to hear judgmental voices during performance that undermine self-efficacy, as well as steer attention towards mistakes and internal focus, and away from the overall musical message.

On a final note: live performances are much more compelling than recorded ones. Many students at colleges and conservatories complain that their professors are unwilling to play for them or with them – although this century-old tradition is a necessary part of good instruction. Competition between students often prevents them from playing for and helping each other, although both of these are the ingredients of popular, informal music education. Following the arguments presented in this paper, an increased awareness of the importance of observation and imitation, music making within the lesson can be rediscovered as an essential part of musical training.

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Biographies of authors and presenters

ECKART ALTENMÜLLER

Hanover University of Music, Drama and Media, Hannover, Germany

Eckart Altenmüller is a full university Professor and medical Doctor, and has an active research and concert career. He graduated in medicine and in music at the University of Freiburg, where he obtained is concert diploma in the master classes of Aurèle Nicolèt and William Bennett. His clinical training was in the department of neurology in Freiburg and Tübingen as a neurologist and neurophysiologist. In 1994, he became Chair and Director of the Institute of Music Physiology and Musicians' Medicine at Hannover University of Music and Drama, a position he has held for the past 19 years. In this role, he has continued his research into sensory-motor learning and movement disorders in musicians. Dr. Altenmüller is member of the prestigious Göttingen Academy of Sciences since 2005 and President of the German Society for Music Physiology and Musician's Medicine 2005-2011, Vice-President since then.

PÄIVI ARJAS

Sibelius Academy, Helsinki, Finland

Päivi Arjas, born in Helsinki Finland, studied music education at the University of Jyväskylä and violoncello at the Conservatoire of Kuopio. She works at the Sibelius Academy (Helsinki, Finland) as the head of the string department, as well as being a lecturer of performance coaching. Earlier she worked as cello teacher at The Finnish Conservatoire, (Jyväskylä), in several music schools and at the Jyväskylä University of Applied Sciences. She has been a member of the AEC Polifonia pre college-working group and has published books about performance anxiety and mental training for musicians. She works regularly as a visiting lecturer both in Finland and abroad.

HENK BORGDORFF
Royal Conservatoire, The Hague, The Netherlands

Henk Borgdorff is Professor ('lector') of Research in the Arts at the Royal Conservatoire / University of the Arts, The Hague (The Netherlands). He was professor in Art Theory and Research at the Amsterdam School of the Arts (until 2010) and visiting professor in Aesthetics at the Faculty of Fine, Applied and Performing Arts at the University of Gothenburg (until 2013). Borgdorff is editor of the Journal for Artistic Research. At the Royal Conservatoire he focuses on the strengthening of the research culture and infrastructure, in both the degree programmes and on faculty level. His has published widely on the theoretical and political rationale of research in the Arts. A selection is published in May 2012 as *The Conflict of the Faculties: Perspectives on Artistic Research and Academia* (Leiden University Press).

FRANK HECKMAN
Codarts, University of the Arts, Rotterdam, The Netherlands

Coach, traveller, organizational expert and movement specialist Frank Heckman is the 'Sustainable Performance' lector at Codarts, University of the Arts in Rotterdam and introduced the phenomenon of 'flow' into the Netherlands. Heckman (Den Haag, 1950) is an expert in the field of leadership, performance and learning processes. As a social architect and mystic he works in the peripheral areas between spirituality and business. Along the way he has applied the concept of flow to Olympic athletes, the business world, a North American Indian tribe and 'problem youth' in the ghettos of Chicago.
– 'Flow is the innate ability to be fully involved in the activity one undertakes. It is a heightened state of attention, a natural state within the reach of every living soul'.
Frank is founder of The Embassy of the Earth, and author of *The Hero's Journey*, a book about Olympic athletes and coaches on their way to the 2004 Olympics in Athens.

ERJA JOUKAMO-AMPUJA
Sibelius Academy, Helsinki, Finland

Erja Joukamo-Ampuja graduated from the Sibelius Academy 1987 making her Master of Music with excellent degrees and she has completed her studies (1984-2001) in Norway, Austria, Germany, England, Canada and USA with famous pedagogues. She has made her licenciat research work in 2010 at the Sibelius Academy. Joukamo-Ampuja has played with the Finnish Radio Symphony Orchestra (1984-2001) and has been teaching the French Horn at the Sibelius-Academy since 1987, now being a Professor of Horn and Pedagogy and Art Education. She is also a certificated ear-training teacher. She is an active recitalist and a chamber musician as well as a well-known lecturer and a teacher, and has been giving master classes and lectures in Scandinavia, Europe, Australia and USA.
Erja has also participated in various research projects.
In teaching and lecturing Erja Joukamo-Ampuja has specialised in

- Mental practicing in music teaching / performing
- Creative approach to teaching and improvising
- Teaching practicing skills and strategy (lectures prepared together with a medical doctor)

WIEKE KARSTEN
Royal Conservatoire, The Hague, The Netherlands

Flutist Wieke Karsten studied at the Royal Conservatory in The Hague and in England with the famous flute pedagogue, Trevor Wye. Her interest in teaching already came to light as a student and upon graduation she was appointed as flute teacher at the conservatories of both The Hague and Groningen.
Wieke created a method 'Making music, practising and the brain'. This focuses on the relation between practising and performing under stress, training attention and practising interpretation and expression. Concerning this topic Wieke coaches individual musicians and gives

workshops and lectures in the Netherlands and abroad. She has a regular column focusing on teaching in several instrumental magazines, such as Fluit, Flöte Aktuell, Arco and Klarinet. Since 2009 Wieke is teaching at the Dutch Flute Academy (www.Neflac.nl). In 1998, together with pianist Henry Kelder, she won first prize at the International Friedrich Kuhlau Flute Competition in Germany. The duo released until now two CD's. Since September 2013 Wieke is appointed as master research coach at Codarts Rotterdam, in the domain of Sustainable Performance.
www.wiekekarsten.nl

GABRIELA MAYER
CIT Cork School of Music, Cork, Ireland

Dr Gabriela Mayer is currently the Head of the Department of Keyboard Studies at Ireland's largest music conservatoire, the CIT Cork School of Music. As a recipient of a Fulbright Graduate Fellowship to Germany in 1997, Ms. Mayer studied piano performance at the Hochschule für Musik 'Hanns Eisler' in Berlin. She also completed a Doctorate in Musical Arts at the University of Maryland in the USA, graduating with the highest honours. In America, she taught at the American University in Washington DC and Smyths College in West Virginia. Since moving to Ireland, she has been teaching as well as performing both solo and chamber music recitals. In addition, she has promoted awareness of health and performance issues in her school through organising workshops and lectures. Her own interest is in the area of Reflective Practice and utilising coaching techniques to improve student performance and develop self confidence.
She has been involved in activities of the Association of European Conservatoires (AEC) and European Piano Teachers Association (EPTA) through participation in seminars, giving presentations at conferences on pedagogical and performance topics and as an international representative of the AEC on institutional review panels. Her students have won prizes and awards in piano performance and chamber music competitions and many of the MA graduates she taught have secured professional careers as musicians.

ADINA MORNELL
University of Music and Performing Arts in Munich, Germany

Born in Los Angeles, Adina Mornell is a classical pianist and recording artist who studied Music, American Literature, Musicology, and Psychology, receiving degrees in the United States, Germany, and Austria, the latter being a doctorate in Music Psychology. She is currently Professor of Instrumental and Vocal Pedagogy (IGP) at the University of Music and Performing Arts in Munich, Germany. Her book on stage fright, *Lampenfieber und Angst bei ausübenden Musikern*, is one of the few scientific publications on the topic in the German language.
She is responsible for the book series *Art in Motion. Musical and Athletic Motor Learning and Performance*, and regularly publishes articles about art and science.
In addition to her empirical research on musical performance and expertise, and her career as a concert artist, she is active as an educator for musicians and music teachers, as well as for executives and managers, at institutions of higher education in both Europe and the United States.

EVE NEWSOME
Queensland Conservatorium Griffith University, Australia

Eve Newsome has had a versatile and exciting career as an orchestral, chamber and solo player of oboe, oboe d'amore and cor anglais. Several awards allowed her to undertake advanced oboe study in Europe and improvisation studies in London. She has been appointed to orchestral positions in the Queensland Philharmonic Orchestra, the Melbourne Symphony and Orchestra Victoria and guested with the Australian Chamber Orchestra, the Singapore Symphony and the Sydney, Adelaide and Queensland Symphony Orchestras. Eve is Lecturer in Woodwind at the Queensland Conservatorium, Griffith University (QCGU) and performs with the ensemble-in-residence, the Lunaire Collective. She is a PhD

candidate at QCGU specialising in optimal experience and music performance.
She is a founding member of a range of ensembles including the recently formed Brisbane-based ensemble The Lunaire Collective, an Ensemble in Residence at the Queensland Conservatorium in 2013.

SABINE SCHNEIDER

Clinical psychologist in free practice, Hannover, Germany

Sabine Schneider is a professionally trained guitar player, psychologist and neuropsychologist. She studied music for 5 years and after that Psychology for 4 years in Magdeburg, Germany. 2002-2005 Sabine worked at the University of Magdeburg at the Department of Neuropsychology, and in 2005 she started her work at the Institute of Music Physiology and Musician´s Medicine, University of Music and Drama Hannover. She received her PhD in 2007 in Magdeburg. Sabine established the MUT training, a novel therapy in stroke patients, using piano playing and drumming to regain fine- and gross motor control.
Currently Sabine is in free practice as a clinical psychologist in Hannover.

SUSAN WILLIAMS

Royal Conservatoire, The Hague, The Netherlands

Susan Williams has been a professional trumpeter for over 30 years and has performed and recorded with many of Europe's finest early music ensembles as soloist as well as in orchestral and chamber music. She continues to perform and also teaches natural trumpet in both the Royal Conservatorium of The Hague and at The University of the Arts Bremen, as well as leading and conducting projects. She has designed and created many workshops and projects herself – most notably with her own group, Clarini.
In addition, Susan teaches practicing and performance courses in both of the above named institutions. Her interest is in developing structures which facilitate self-training and are based on holistic principles. The focus of her PhD research is on investigating auditory imagery and its effects on accuracy and confidence.

GABRIELE WULF

University of Nevada, Las Vegas, United States

Gabriele Wulf is a Professor in the Department of Kinesiology and Nutrition Sciences at the University of Nevada, Las Vegas (UNLV). Dr. Wulf studies factors that influence motor skill learning, such as the performer's focus of attention, motivational effects of feedback, learner-controlled practice, enhanced performance expectancies, and conceptions of ability. Her research has resulted in more than 160 journal articles and book chapters, as well as two books. Dr. Wulf has received various awards for her research, including UNLV's Barrick Distinguished Scholar Award. She currently serves as the President-Elect of the North American Society for the Psychology of Sport and Physical Activity (NASPSPA). In addition, she has served as the founding editor of Frontiers in Movement Science and Sport Psychology (2010-2012). and since 2012 as the founding editor of the Journal of Motor Learning and Development.

Recommended reading

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Colophon

From Potential to Performance
is a publication of the
Royal Conservatoire

Authors:
Eckart Altenmüller
Päivi Arjas
Henk Borgdorf
Erja Joukamo-Ampuja
Wieke Karsten
Gabriela Mayer
Adina Mornell
Sabine Schneider
Susan Williams
Gabriele Wulf

Editors:
Marijke van den Bergen
Henk Borgdorff
Wieke Karsten
Susan Williams

Design:
Thonik, Amsterdam

Print:
De Swart

Royal Conservatoire
The Hague 2014
www.koncon.nl

ISBN: 978-90-822138-0-5

Authors

Eckart Altenmüller
Päivi Arjas
Henk Borgdorff
Erja Joukamo-Ampuja
Wieke Karsten
Gabriela Mayer
Adina Mornell
Eve Newsome
Sabine Schneider
Susan Williams
Gabriele Wulf

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