Universiteit Leiden

Psychologie
Faculteit der Sociale Wetenschappen

The Art of Application

A thesis in cognitive psychology on professional musical practice behavior

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Date: 22 - 02 - 2017

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Cognitive Psychology
Thesis Msci Applied Cognitive Psychology

Content

Abstract

The aim of this thesis report was to readdress and relate several conclusions from research on professional musical practice behavior within one study, and with more concise scales. As expected, practice time was not a significant predictor of conservatoire performance grades in a Multinomial Logistic Regression Analysis (MLRA), but contrary to expectations, neither were the computed formal practice variables 'goal-driven practice' and 'focus', or interactions of these variables with practice time. Some support was found for the hypothesized positive effect of a larger number of strategies on exam grades, but not for the effect of an interaction between formal practice and the number practice strategies. No significant differences in formal practice or number of strategies were found between students in the first year of the bachelor, and students in the master, suggesting a lack of development on these aspects over the course of professional music education. Differences on these variables were also absent between jazz- and classical musicians. Some limitations on the measures are discussed. Especially the use of students' performance exam grades as measure of musical achievement is taken into consideration: exam grades appeared to be mainly related to study year, musical department, and years of performing experience with the instrument.

General introduction

Music for scientists

Making music is seen as one of the most complex procedural skills that humans can acquire (Altenmüller, 2008; Küpers, van Dijk, McPherson, & van Geert, 2014; Wulf & Mornell, 2008). It demands the development and collaboration of many abilities: for example motoric, sensory and temporal, but also creative, communicative and emotional (Altenmüller, 2008; Limb & Braun, 2008). Because of its high complexity, learning to perform music is interesting for scientists: motor skills and procedural learning were first studied with simple skills, but later it appeared that findings on simple procedural and motor learning cannot just be translated to complex tasks, so complex motor learning should be studied in itself (Donovan & Radosevich, 1999; Van Gog, Ericsson, Rikers, & Paas, 2005; Williamon & Valentine, 2000). Real life-long- developing activities like music are useful for this domain of theory development (Münte, Altenmüller, & Jancke, 2002).

Music education is also interesting for research on topics related to learning. Küpers et al. (2014) and Varela, Abrami, and Upitis (2016) argue that few things need as much motivation, self-determination and self-regulation as learning a musical instrument, both in the early stages and in the long run. Studying musicians and musical apprentices can therefore help to develop insights in motivation theories, education theories, and combinations of those (Evans & Bonneville-Roussy, 2015; Küpers et al., 2014).

Science for musicians

Making music is of course not the only interesting field for research in complex motor skills. There is an extensive record of studies and theory development in motor skills and procedural learning, from arithmetic to golf, and from chess to laparoscopic surgery (Bonneville-Roussy & Bouffard, 2015; Porter & Magill, 2010; Spruit, Band, Hamming, & Ridderinkhof, 2014; Sweller, van Merienboer, & Paas, 1998). Cognitive science can offer many valuable insights for application in the studied fields, like surgery, sports, and music. But compared to sportsmen, musicians have long been hesitant to involve scientific research and recommendations in their field. According to Wulf and Mornell (2008), this has been at least partly because many musicians saw their profession as an art, and not as something analyzable. In view of the competitive essence of sports, sportsmen may be more willing to analyze everything they do, while the musicians' goal is to convey musical intentions (Yoshie, Shigemasu, Kudo, & Ohtsuki, 2009) (although the current music scene is becoming more and more competitive too). The artists' work and their behavior being analyzed in a scientific way was often seen as something destructive or impossible, or both. This may be one of the reasons that cognitive research in performing arts has not developed as much as in sports, for example.

However, making music is cognitively such a complex skill, that one just cannot learn it optimally through trial-and-error, or by following own beliefs and intuition only (Lehman & Ericsson, 1997; Schmidt & Bjork, 1992). Scientific studies and theories on how one should learn, teach and practice the skills needed to perform music are now beginning to be applied by musicians and conservatoires (Koopman, Smit, de Vugt, Deneer, & den Ouden, 2007; Wulf & Mornell, 2008; Burwell & Shipton, 2011, Zhukov, 2009). Especially individual instrumental (or vocal) practice seems a topic that could benefit from applying science, if we consider the high and growing number of available scientific insights, the daily hours that professional musicians and students commit to practicing their instrument, and the relatively low amount of research-based training that many students receive to use this time constructively (Gabrielsson, 2003; Miksza, 2015; Nielsen, 2004).

This master's thesis in Applied Cognitive Psychology aims to bridge the gap between this scientific discipline and the status quo of individual practice development in professional music education. On the basis of central theories over the last two decades of research in this field, students of a specific conservatoire are studied to evaluate their practice behavior and its development throughout the curriculum. From a scientific point of view, it is interesting to see if earlier findings are robust enough to be replicable on the level of a specific conservatoire, with more concise scales than the mostly exhaustive ones that were initially used to investigate specific factors. The practical relevance of such a broad but concise survey would be that teachers and students in higher music education can be served with a study that shows the relevance of several concepts together, specifically measured on their conservatoire. In this way, a conservatoire could evaluate - and eventually consider how to improve- the practice behavior of students on a range of relevant aspects, without the impossible effort of asking students to fill in a list with hundreds of questions. In order to introduce the hypotheses and method of this study, I will now first provide an overview of relevant concepts and theoretical developments.

Theoretical introduction

It is not in the scope of this theoretical introduction to develop an exhaustive overview of all topics that have been addressed by expert performance researchers in the last twenty years. Moreover, I will establish a central foundation on practice behavior and learning, to facilitate evaluation of current practice behavior in the following study. I will first shortly discuss two major tracks in practice research called deliberate practice and self-regulation, and their combination in the concept of formal practice. After that, I will discuss research on more practical practice strategies.

Practice time, practice quality and formal practice

Simply making many hours of practice is presumably not the best thing a student or musician could do. It is not about how much time a student spends with the instrument, but what he or she actually does during this time (Burwell & Shipton, 2011; Jørgensen, 2002; Miksza, 2007; Williamon & Valentine, 2000). The discussed studies all mention that considering the quality of our practice time is beneficial or crucial. So, what makes practice qualitatively better? Two central theories concerning practice quality are deliberate practice and self-regulation.

Deliberate practice

Research on instrumental musical practice, and expertise in general, was boosted by the now famous study with violin students of Ericsson, Lehmann, and Tesch-Römer (1993). Their introduction of the term deliberate practice provides valuable insights: learning, and what we call deliberate practice, has the central purpose of acquiring knowledge or skill. Opposed to other activities like work or play, the skill is not used for any goal, but the goal of the activity is to improve that specific skill itself. So the only purpose of practicing should be to learn something, and all activities should accurately serve this goal of learning.

The article of Ericsson et al. (1993) is a firm nurture-statement in the nature-nurture debate: the authors pose that such a thing as talent does not exist, as expertise in any field would be reachable with at least 10.000 hours of deliberate practice. Since its introduction as only factor underlying expertise, the role of the amount of deliberate practice has been nuanced by several authors. Reconsidering research on deliberate practice in chess and music over 20 years, the amount of deliberate practice was concluded to account for a third of the variance in achievement (Hambrick, Oswald, Altmann, Mainz, Gobet, & Compitelli, 2014). This is still a large effect, while this amount of deliberate practice only contains one qualitative aspect yet: having improvement as central goal. Williamon and Valentine (2000) already concluded that the amount of deliberate practice is only the surface for research on learning complex skills like music, and that it is useful to investigate other factors of practice quality too.

Self-regulation

Another, related track in practice-research has been self-regulation. Practice is deliberate if improvement is the goal, but one needs different forms of self-regulation to actually reach this goal. In short, self-regulation is about actively arranging your own thoughts, feelings, and actions to reach your goals (McPherson, Nielsen, & Renwick, 2013; Schunk & Zimmerman, 1998; Zimmerman, 1998a, 1998b). Researchers made many different models within the concept self-regulation. Zimmerman's model has been influential for research in many educational settings like professional writing, sports,

music and academic studying (McPherson et al., 2013; Miksza, 2015; Varela et al., 2016; Zimmerman, 1998a, 1998b). According to Zimmerman (1998b), self-regulated practice contains a cycle of three important activities: forethought and planning before playing; self-control and self-awareness during playing, and reflection and evaluation after playing. He also categorized self-regulatory processes into: making a certain motivation to practice (goal setting); making methods to practice (task strategies, imagery, self-instruction); time management; behavior management (self-monitoring, self-evaluation); and resource management (structuring the environment and seeking help) (McPherson et al., 2013; Zimmerman, 1998a).

This is however not the only categorization, there have been different but comparable models to categorize such learning strategies. Nielsen (2004) for example developed a 50-item music practice version of the Motivated Strategies for Learning Questionnaire (MSLQ), in which she described three categories: Cognition (e.g. focus on the aspect that should be practiced and practice content), Metacognition (thinking about cognition, e.g. planning and evaluation), and Resources (information seeking, help seeking, time, and motivation). Araújo (2016) developed even another, but comparable categorization of self-regulation strategies: Practice Organization, Management of Personal Resources (e.g. knowing own strengths and weaknesses), and Management of External Resources (e.g. help seeking). Such a multitude of different models of Zimmerman (1998a), Nielsen (2004) and Araújo (2016) can be difficult to understand and use simultaneously, while they actually all consider at least two major aspects, namely the organization of practice activities[1], and the management of resources[2]. These different categorizations may all have their strengths and contributions, but recognizing such commonalities between theories can be useful.

Formal practice as overall concept

With so many different but related conceptualizations of practice quality in deliberate practice and self-regulation, it is important to develop a broad framework. This would afford a better understanding of relevant commonalities, communication and comparison among theorists, as well as easier evaluation and teaching of actual practice behavior. Varela et al. (2016) conducted a meta-analysis in an attempt to develop a more cohesive framework on self-regulation, without much success. They found mostly positive, but weak and inconsistent relations between self-regulation and other aspects like level of expertise, performance scores, and amount of practice. According to

[1] Motive and Methods to practice, according to Zimmerman (1998a); Cognition and Metacognition according to Nielsen (2004); Practice Organization according to Araújo (2016)

[2] Time, Behavior, and Resource management according to Zimmerman (1998a); Resource Management according to Nielsen (2004); Personal and External Resources according to Araújo (2016)

Bonneville- Roussy and Bouffard (2015), considerable literature suggests that self-regulation is actually an indirect determinant of performance.

Bonneville- Roussy and Bouffard (2015) made a fruitful step towards a central framework, by combining the theories of deliberate practice and self-regulation as parts of a central concept called formal practice. They were not the first to use the terms formal and informal practice. In the study by Sloboda, Davidson, Howe and Moore (1996) formal practice was only defined as the use of any goals during practice, as measured with one self-report question. This definition is broad, but moreover a vague version of the definition for deliberate practice. Bonneville- Roussy and Bouffard (2015) redefined formal practice as a combined construct of deliberate practice and self-regulation characteristics. Summarizing these concepts together, formal practice was now defined by two main criteria: mental focus on the practiced content, and the use of improvement goals to guide practice behavior. Strategies from deliberate practice and self-regulation would serve these core aspects. They found that practice time in itself is negatively correlated with performance, but mediated by this new construct of formal practice, practice time was positively associated with achievement in a path-analysis. Also, deliberate practice and self-regulation accounted for more variance in achievement when combined in the construct of formal practice than their separate contributions together.

Informal practice, opposed to formal practice, is any practice behavior that doesn't meet the two criteria of goal-driven activities, or focused attention (Bonneville-Roussy & Bouffard, 2015). Examples include unstructured activities, or always playing through pieces in a row (Sloboda et al., 1996). Informal practice can have some benefits like increased motivation, but it does not seem effective for learning (Bonneville-Roussy & Bouffard, 2015). There might however be a difference for jazz musicians: Much of the research on the topic of musical expertise was done with classical musicians (Gabrielsson, 2003), leading to conclusions that might not hold for learning the necessary skills to function as a jazz musician. For example, a neuroimaging study by Limb and Braun (2008) showed a different pattern of activation in the prefrontal cortex when jazz-musicians improvised, compared to when they learned and performed prescribed melodies. The authors suggested that forms of activity in the prefrontal cortex that were associated with self-monitored practice might be detrimental to the creative process of improvisation. However, Bonneville- Roussy and Bouffard (2015) found a benefit for formal practice with a sample that consisted for about a third of jazz students (51 out of 173). They claim that improvisation can and should be practiced formally too, with goal direction and focused attention, using self-regulation and deliberate practice strategies, in order to improve.

In essence, the formal-practice framework can be seen as a way to touch the central aspects of different effective methods: if any method makes students mentally focused in a better way, or more active in achieving the goal of increasing skill, it can at least partly be understood and supported through this formal practice model (Bonneville-Roussy & Bouffard, 2015; Lehmann & Ericsson, 1997). I will now discuss the use of practical practice strategies in the light of this formal practice framework.

Practice strategies

Self-regulation theories address practical strategies to learn material ('cognition' in the SMLQ (Nielsen, 2004); 'practice organization' in the model of Araújo (2016), 'Methods to practice' according to Zimmerman (1998a)). Practicing with the intention to learn something (as to say, deliberate) is fruitful, and knowing how to keep ourselves concentrated too, but what activities make us actually learn better? Mere repetition is still popular among musicians, but definitely not the best way to practice (Wulf & Mornell, 2008).

I will start with two examples, leading up to the statement that we should not necessarily think of 'right' and 'wrong' practice strategies. I will then describe some practice strategies and their effect in the light of Cognitive Load Theory.

Two examples from random practice research

As I said, people often repeat small parts of music over and over again, 'drilling' the music into their memory. After this, they take another part, and 'drill' it. This 'drilling' is also called blocked practice. At the end of the session, significant advances are made, but after some days much of this progress is lost (Schmidt & Bjork, 1992). With the strategy called random practice however, the practiced sequences are mixed during the session: a sequence or excerpt is played once, then another piece of material, then a third, and then the first one again, then the third, etcetera. This is experienced as less comfortable and less beneficial, and at the end of the session the progress is less compared to blocked practice. But after some days, much of the progress is still there, significantly better than blocked practice. This effect has been shown for many different procedural skills (Porter & Magill, 2010; Schmidt & Bjork, 1992; Wulf & Mornell, 2008).

This random practice example is illustrative for the pattern that initial performance increases during a session can be misleading, as they are not related to real learning of a skill (Schmidt & Bjork, 1992). With real learning, I mean retrievable storage of information (also skills) in our long term memory. Really learned skills are still measurable in terms of retention (a later moment in time) and transfer (a new, unpracticed activity that requires the same skill) (Schmidt & Bjork, 1992). However, even when students are confronted with the benefit of random practice on their own learning, they

still prefer blocked schedules, because they felt it was more beneficial during the session itself (Kornell & Bjork, 2008; Kornell, Castel, Eich, & Bjork, 2010).

The previous example on the effect of random practice should not be interpreted in a way that random practice is always better than blocked practice. Recently Stambaugh (2013) showed that random practice is not always the best technique. She compared the effect of blocked and random practice schedules on the same challenging material for brass and woodwind students in an experimental study. As expected, woodwind players performed better on a retention test (the next day) after random practice, compared to blocked practice. Brass players however showed lower performance on the same material throughout the study, but also had more benefit from blocked than from random practice on this retention test. The conclusion that random practice success would directly depend on the kind of instrument is not plausible. Rather, Stambaugh (2013) inferred from the lower overall performance of the brass students that the same material was more difficult to play on brass than on woodwind instruments. In short, the production of correct notes depends more on the precise interaction of the mouth and hands with brass than with woodwinds. The task was by nature cognitively more loading (more things to think about at the same time) for brass players than for woodwind players. Increasing the difficulty with a random practice schedule was therefore counterproductive for the brass players. Porter and Magill (2010) found that a practice schedule with a gradual replacement of blocked by random practice was better than either blocked or random practice: in the beginning it seems better to repeat and figure things out, and gradually increase the difficulty by mixing the practiced motives.

It's not about any 'right' strategies

Schunk and Zimmerman (1998) stated that "no single learning strategy will work equally well for all students, and few, if any, strategies will work optimally on all academic tasks. The effectiveness of a strategy will be prone to change as a skill develops …" (p. 2). Knowing any specific strategies does not seem important. It does seem important to know and frequently use different strategies on the moment that they are specifically useful. Williamon and Valentine (2000) and Nielsen (2004) found that better students made more switches between technical and musical focus in practicing a piece, and applied more different practice methods on one piece.

However, musicians could better apply strategies consciously on the moment that they are useful within goal-directed practice, than using them at random: Miksza (2007) reported several practice strategies that were associated with greater performance increases (repeat section, slowing, whole-part-whole, and skipping directly to or just before critical musical sections), but all on specifically different moments in the practice period of a piece, and not in a clear pattern. In a later

study, Miksza (2015) randomly assigned music students to two groups: the first group received training in practice strategies that were associated with increased performance (Miksza, 2007). The other group received the same instructions on practice strategies, but was also trained to use these in combination with self-regulation principles (among others goal-selection, self-evaluation, reflective activities, planning). This second group showed higher performance increases, and reported more musical and nuanced practice goals.

To summarize, students should not just be taught to apply certain specific strategies. Rather, better students seem to have more strategies at hand. In accordance with the formal practice framework, it seems especially beneficial to know why a strategy works and choose to apply it accordingly. One way to understand the effect of practice strategies is through Cognitive Load Theory (Bonneville-Roussy & Bouffard, 2015). It is not the only determinant, but it is a useful start to understand why strategies like random practice sometimes work, and sometimes do not.

Practice strategies and Cognitive Load Theory

I will describe some practice strategies and their effect in the light of Cognitive Load Theory (Sweller et al., 1998; Van Gog et al., 2005). In short, it assumes the following (for a more thorough explanation, see Sweller et al., 1998): human beings have an 'unconscious' unlimited long term memory, in which knowledge is stored, by consciously processing it with our short term memory - also called working memory. However, our working memory can only consciously process a limited amount of information at the same time. If an activity (or several simultaneous activities) requires too much cognitive effort, we cannot perform this activity and do not learn either (Sweller et al., 1998). In order to perform or learn such a difficult activity (or combination of activities), we should learn separate parts or simplified versions first. To recall the examples on random practice: random practice is challenging, so it can be useful by engaging our working memory, but it can be detrimental if the exercise was already difficult in itself. Porter and Magill (2010) found the most benefits for systematically increasing the difficulty, by gradually shifting from blocked to random practice schedules. I will discuss some common strategies as either increasing, or decreasing cognitive load.

Increasing cognitive load

In order to learn, our working memory should be actively involved in the task. Deeper and more diverse processing of the information leads to higher retrievability of knowledge: Bjork (1994) introduced the term 'desirable difficulties' to describe the use of methods that decrease our current performance, but increase our cognitive engagement and thereby our real, long term, learning of a skill. I already introduced *random practice* as such a method. The principle of *spaced* -opposed to massed- practice is to spread the training a skill over several moments in consecutive days or weeks,

instead of concentrating all practice in one large session or consecutive sessions on the same day (Spruit et al., 2014; Donovan & Radosevich, 1999). Random practice and spaced practice are at least partly effective because it takes greater effort to recall the skill after doing or learning other things in between. This mental effort enforces the ability to recall the skill in the future. This effect is called contextual interference (Boutin & Blandin, 2010; Porter & Magill, 2010). It can also be useful to introduce *variability*. For example, by hand reversal, or changing the key, tempo, articulation, and so on (Zhukov, 2009). Varying musical aspects (intention, style, metaphors) might be even better, as it could be seen as a form of external focus of attention. External focus of attention can be described as thinking about the effect instead of the bodily action itself, and is shown to be effective for many motor skills in different contexts (Wulf & Lewthwaite, 2016).

Decreasing cognitive load

In the earlier described study on random practice for woodwind and brass players (Stambaugh, 2013), brass players were cognitively still so busy trying to play the sequences anyway, that it was useless to add a random practice schedule, which only increased the cognitive load beyond the limits of their working memory. Donovan and Radosevich (1999) also concluded that the benefit of spaced practice for simple tasks did not hold for tasks with more difficulty. Sometimes we should repeat, or find even more effective methods to lower the cognitive load of a task. I will give some examples of such strategies.

A large group of common strategies is characterized by *splitting the task* into smaller parts, or practicing a *simplified version* first (leading to a lower intrinsic cognitive load, Sweller et al., 1998). For example, practicing both hands separately on the piano before practicing both hands together, slowing down the tempo, playing something first without and then with a certain articulation, and so on (Miksza, 2007; Zhukov, 2009).

Observational practice works well for such complex skills as making music and surgery (Wulf & Mornell, 2009; Wulf, Shea, & Lewthwaite, 2010). Observation can be seen as a cognitively efficient, non-verbal version of explanation, opposed to being explained in words or finding out yourself. Observational practice is not only beneficial when you see a superior musician, it may even work when this person is less skilled than you, if you can identify mistakes (Wulf & Mornell, 2009).

Mental practice partly works for the same reasons as observational practice, in the way that seeing someone else perform an activity or vividly imagining to perform the activity, is neurologically almost identical to doing it physically. However, it does not strain the muscles (Altenmuller, 2008; Wulf & Mornell, 2008; Bernardi, De Buglio, Trimarchi, Chielli, & Bricolo, 2013). When learning a difficult skill, it can be good to enforce a mental model on the skill by thinking about it, next to

spending cognitive effort on actually doing it (Driskell, Copper, & Moran, 1994**;** Hall, 2002; Avanzino et al., 2009). This does not mean that physical practice can be substituted by mental practice. Especially the tasks that are experienced as difficult should be extensively practiced physically too, because mental practice does not provide any feedback (Cahn, 2008; Driskell et al., 1994).

Summary

To summarize this theoretical introduction briefly: practice time is presumably only relevant if we consider the quality of this time too. The tracks of deliberate practice and self-regulation (and maybe others too) can be combined in the summative concept of formal practice, defined by focused practice directed by learning-goals. Specific practice behaviors are not either effective or ineffective in themselves: Having many strategies available and knowing when to use them appropriately is more important. Strategies can be applied more usefully within formal practice. In the next study, these conclusions are applied in an investigation of the practice behavior of students on a specific conservatoire.

Hypotheses

In the theoretical introduction, I explained that scientists and musicians should strive to combine as many relevant factors as possible in one joint framework on musical practice behavior. I described the concept of formal practice as such a combination of different effective theories (Bonneville- Roussy & Bouffard, 2015). The aim of this study was to replicate some central findings on a single conservatoire, with more concise scales. This is the thesis report of a survey that was executed on the Royal Conservatoire in The Hague. This thesis report focusses on a limited set of hypotheses. For a broader, more practical discussion of the results of the survey I refer to the practical survey report in Appendix D. I will now discuss the four hypotheses that are considered in this thesis. They respectively address (1) the relevance of practice time and formal practice; (2) the use of practical practice strategies; (3) the development of practice quality throughout the curriculum; and (4) possible differences in effects between the jazz and classical department.

Hypothesis 1: I hypothesize that practice time is not positively associated with performance (Burwell & Shipton, 2011), unless it is associated with practice quality, as defined by formal practice characteristics (Bonneville-Roussy and Bouffard, 2015). This hypothesis can be split into three steps:

Hypothesis 1a: Practice time is not a positive predictor of musical achievement.

Hypothesis 1b: Formal practice is a positive predictor of musical achievement.

Hypothesis 1c: An interaction of formal practice and practice time is a positive predictor of achievement.

Hypothesis 2: Next to, and in addition to the role of formal practice, it is interesting to find further support for the claims that frequent use of more different practice strategies is associated with higher achievement (Gabrielsson, 2003; Miksza, 2015; Nielsen, 2004; Williamon & Valentine, 2000). This hypothesis consists of two sub hypotheses:

Hypothesis 2a: The use of any specific strategy is not related to achievement. Rather, the number of different practice strategies that a student uses is expected to be a positive predictor of achievement

Hypothesis 2b: An interaction of formal practice and number of strategies may be even more prominent in positively predicting achievement.

Hypothesis 3: Throughout the curriculum, students may develop practice quality, in measures of formal practice and use of different practice strategies. For any conservatoire it is of crucial importance to see if students develop individual practice skills. I expect that students in the end of their studies show more signs of formal practice, and use more different practice strategies frequently than students in the first year.

Hypothesis 4: jazz students may differ from students in the classical department, in their use of formal practice and strategies. This hypothesis is somewhat premature, but finding such a difference between disciplines would prevent overgeneralization, and such differences would be important to investigate further.

Hypothesis 4a: Formal practice strategies may not be used as much by jazz students as by classical music students.

Hypothesis 4b: Also, formal practice strategies may not be as beneficial for jazz students as they would be for classical students.

Method

Participants and procedure

The survey was only spread among students of the Royal Conservatoire in The Hague. The aim was to reach as many students as possible from different study years and instruments. Respondents were however only included in the analyses if they met the following criteria: following a fulltime bachelor, master or preparatory year; in the classical, jazz, or early music department (students in music education, composition, or anything else were excluded, because their instrument is not the main activity of the course); and responded to a final five-point question "*Did you understand the questions?*" with "*Most*" or higher. The survey was spread in April and May 2016, during lessons and in the canteen of the conservatoire. Next to the written introduction of the survey (appendix C), students were also informed in a spoken way. Students were requested to fill in their student number, and were informed that: their student number would be used to involve their exam grade in the analyses; they were not obliged to fill in their student number; their answers and grade would be treated anonymously. After a survey was turned in, the student-number was torn from the form, and both parts got a corresponding participant number. The student-numbers were (and are) kept strictly separate from the other answers.

Measurements and analyses

As mentioned, the students were asked for their student number to use their end-of term grade, which is given on the basis of an exam performance, by a committee of at least three people. This grade is the first central measure, namely for achievement. This grade is a measure that every conservatoire could easily provide (with approval of students), and is in a certain way even credible for causal suggestions, as these graded exam performances are seen as a central goal of practice during the study year, especially during the period in which students filled in this survey. This grade is also used as a measure of achievement in comparable studies (Bonneville-Roussy, & Bouffard, 2015; Burwell & Shipton, 2011; Jørgensen, 2002). In the studied Dutch conservatoire students can receive a grade from 1 ('extremely poor') up to 10 ('excellent'). In reality, 4 is sometimes displayed as the lowest conventional option for a grade on the forms of the conservatoire. Only on the final exams of bachelor or master courses, students can also receive a half point-scaled grade (e.g. '7.5', '8.5'), as average of the jurors judgement.

The relations between achievement on the end-of-term exam and practice time, practice quality, and strategies would be analyzed through regression analyses, either linear or logistic, depending on the characteristics of the data. On inspection, the end-of-term exam grades did not meet the assumptions for a linear regression model, as the residuals were not distributed normally.

Also, instead of some dispersion of grades over the official scale from 1 to 10, there were only grades of 6 or higher. In the Dutch grading system, a grade under 5,5 is labeled as insufficient, meaning that none of the students who gave permission to use their grade in this study and actually played a graded exam, were judged to perform insufficiently.

The effects of practice time and practice quality (hypothesis 1) and practice strategies (hypothesis 2) on achievement were tested through multinomial logistic regression analyses (MLRA). To use the end-of-term grades as dependent variable in these analyses, grades were recoded into three categories: Those students who had scored a 6 to 7 (n = 35) were placed in a 'low' group; those who had achieved a 7,5 or 8 (n = 36) in a 'middle' group; those who were granted an 8,5 or higher (n = 24) formed a group of 'high' achievers. The several predictor variables would be entered as standardized, to afford interaction in the regression models.

Survey content

Practice time seems to be well measurable by self-report, as students appeared to be able to report this fairly accurately in previous studies (Jørgensen, 2002; Sloboda et al., 1996). Practice time was measured in two ways: reports of 'actual' daily practice duration and 'normal' daily practice duration. 'Actual' practice duration is computed as the mean of the students' report of their amount of practice in the last three days. 'Normal' practice duration is computed as their reported length of a normal practice session, multiplied by the reported average number of sessions per day. Both measures were compared because one of the two might give a misleading picture: asked for a report of normal daily number and duration of practice sessions, students might for example give their ideal daily practice number instead of the mean of what they actually normally reach. One correction was made in this comparison: in the reports for the last three days students often mentioned a day without practice. Meanwhile, in their report of normal practice session length and usual number of sessions on a normal day, students logically do not correct for their days off. For the comparison with the computed 'normal' practice time, the 'actual' practice time was recomputed in a way that days off were not included. Despite this correction, the computed 'normal' practice time (Median = 3.38) was still significantly greater than students' corrected 'actual' practice time (Median = 3.00; Wilcoxon Signed Rank test: $Z = 3.22$; $p < .005$[3]). 'Normal' practice time might be the daily number of practice that students aim for, rather than their actually achieved practice time. To eliminate this possible bias, and to include the days without practice in the measure of practice time, the original measure of 'actual' practice amount is used as only measure of practice time in the analyses[4].

[3] All *p*-values are displayed as two-tailed.
[4] On inspection, using the 'normal' practice time variable did not change the results for the first hypothesis.

Formal practice was measured with a researcher-constructed scale, based upon other questionnaires and formulations on self-regulation, deliberate practice, and formal practice (Araújo, 2016; Bonneville-Roussy & Bouffard, 2015; Ericsson et al., 1993; Miksza, 2007)). Ten questions were initially considered in this scale, displayed in table 1. Some questions were doubled by an opposite version, to check the consistency of responses. These negative items 2, 7, and 8 were inverted when necessary. Internal consistency checks and principal component analyses (PCA) were executed to derive the list's underling constructs. A reliability analysis was executed on the ten items that were viewed to concern formal practice: Cronbach's $\alpha = .619$, and deleting item 7 or item 9 would heighten the internal consistency to respectively $\alpha = .643$ or $\alpha = .640$.

Because more than one construct was expected, a PCA was first conducted on all ten items (KMO = .682, Bartlett's test: $p < .001$). On first sight, two components with eigenvalues of respectively 2.455 and 1.803 would account for 42.6 percent of the variance: The items 1 to 6 could be interpreted as the use of goals to lead practice behavior, and the items 7, 8, 9 and 10 could well concern the ability to focus on the practiced material. Such a classification would be in accordance with the main components of formal practice, described by Bonneville- Roussy and Bouffard (2015). However, item 9 behaved inconsistently, raising doubts about the validity of this item: next to the detrimental effect on the internal consistency, it loaded on the second component as if it were a negatively framed question, while it was expected to act like a positive statement.[5] Deleting item 9 and forcing the model into two dimensions made the two components account for 45,5 percent of variance in the remaining items (KMO= .688 and Bartlett's test: $p < .001$). The non-orthogonal Oblimin rotation was applied, as these practice characteristics should theoretically be allowed to correlate. The first component (VAF = 26,9%) again consisted of the items 1 to 6 (α= .659), and the second component (VAF = 18.6) was based on the variables 7, 8, and 10 (α= .641). The items and their loadings on the components in this final model are displayed in table 1. As can be seen, the Oblimin rotation clearly increased the distinction between the components, with consistent loadings in both the pattern and structure matrix. On the basis of this PCA, two new variables were computed: 'goal-driven practice' as mean of the first six items (sometimes referred to with 'goals'), and 'focus' as mean of the items 7, 8, and 10. The new variables appeared relatively normally distributed, in terms of Kurtosis (respectively -.37 and -.68) and Skewness (respectively -.408 and .087): All these

[5] Another considered possibility was an Oblimin-rotated solution with three factors: the items 1,3,4 and 6 could stand for the use of goals or metacognition; the items 7, 8, and 10 for the presence of focus, and a third component (eigenvalue= 1,107: accumulated VAF = 53,7) would consist of the items 2, 5, 9, and could be called self- control. Despite sufficient component loadings, the internal consistency of this last group of items was too low (α= 0,389).

measures of (non)normality were not significant (for 'goal-driven practice': zskewness = -1.678 and zkurtosis = -.92; for 'focus': zskewness = -.030 and zkurtosis = .20).

Table 1. Formal practice item means and PCA component loading matrices of the final model.

		Unrotated		Oblimin pattern		Oblimin structure	
Item	**Mean**	**'Goals'**	**'Focus'**	**'Goals'**	**'Focus'**	**'Goals'**	**'Focus'**
1 When something is difficult, I try to find/make exercises to learn it.	4.1	**.521**	.306	**.608**	.079	**.599**	.013
2 My practice is mainly just playing through the music from beginning to end.	2.2	**-.428**	-.185	**-.467**	-.003	**-.466**	.047
3 Before I start playing, I think about one specific thing that I want to focus on.	3.7	**.644**	.257	**.691**	-.015	**.693**	-.090
4 I plan my practice in advance.	3.5	**.486**	.361	**.604**	.144	**.588**	.078
5 When I've set a goal to improve one thing, I stick to evaluating and improving that thing.	3.7	**.602**	.011	**.534**	-.226	**.559**	-.284
6 During practice, I structurally take moments to think about what I want to improve.	3.7	**.692**	.178	**.695**	-.106	**.706**	-.182
7 During practice, I often think about something else while I'm playing.	2.9	-.185	**.757**	.209	**.774**	.125	**.752**
8 During practice I'm often distracted by things like my phone.	2.8	**-.436**	**.636**	-.071	**.760**	-.154	**.768**
9 I can put myself to practice things that I don't like.	3.5	-	-	-	-	-	-
10 When I practice, my thoughts are fully engaged	3.5	**.498**	**-.585**	.151	**-.737**	.230	**-.753**

Note. Questions were framed on a 5 point scale: Ranging from Never (1), to Very Often (5). The means of these answers lay between 1 and 5: closer to 1 would mean more rejection of the statement, closer to 5 would be more affirmative. Means on the negative items 2, 7, and 8 are computed on the original- not the inverted-scores. All component loadings above .400 are bold and underlined. Item 9 was excluded from the final model.

Use of **Practice strategies** was measured as a summarized variable of a list of different practice strategies. Participants were asked to report their use of eleven common strategies (Miksza, 2007, 2011; Wulf & Mornell, 2009) on a 5-point scale (1-5, never - very often). As there are undoubtedly more strategies than eleven, students were asked to fill in any other strategies they used frequently too. A new variable was computed, namely the number of commonly used strategies: all strategies on which a student had reported to use them 'often'(4) or 'very often'(5) were counted, together with any strategies that students might have mentioned in the additional open question on other frequent strategies. A handful of these additionally reported strategies were

excluded by the author, if they were judged to be similar to one of the eleven strategies, while the student had already responded with 'often'(4) or 'very often'(5) on that strategy. The resulting sum of reported strategies was used as the measure of number of frequently used strategies[6].

Study year and **department** (classical, jazz, early music) were also used for testing the third and fourth hypothesis, respectively. Besides, these questions were used for corrections and exploration of the sample, together with other measured personal characteristics like instrument, previous musical education and followed courses on effective practicing. Years of experience in playing the instrument was also investigated: this was asked for both practicing the instrument and performing with the instrument, as these can be differentially influential (Araújo, 2016). All analyses were executed with IBM SPSS Statistics 24.

Results

The survey was initially returned by 147 students in total. After selecting only the full time instrumental and vocal students who reported to understand the questions sufficiently, the remaining sample included 118 students, of which 68 were male, 47 female, and 3 unknown, following bachelor (n= 94) or master (n = 38) courses in the jazz (n = 29), classical (n = 76) and early music (n = 13) departments. 9 students were in a preparatory year. The dispersion of instruments in the sample is displayed in table 1 of appendix D. The respondents were between 18 and 33 years old (M = 23).

The most important measures for testing the hypotheses are summarized in Appendix B, for the total sample as well as for 'low', 'middle' and 'high' achievers. Correlations between these and some other discussed variables are displayed in Appendix A. From 23 students no grade was known, either because they did not fill in their student number or they did not play a graded exam. These participants without a grade did not differ significantly from the others on practice time, use of goals, focus, and amount of strategies (Mann-Whitney U tests and t-tests, smallest $p = .271$). Besides, these students did seem to differ from the other participants in terms of years practicing and years performing with the instrument, and study year (respectively: $U = 801.0$, $p < .05$; $U = 690.5$, $p < .01$; $U = 787.0$, $p = .05$). The 9 students in the preparatory year were also in this group, as they never play a graded exam performance. Excluding these students made the differences insignificant (respectively: $U = 459.5$, $p = .08$; $U = 438.0$, $p = .06$; $U = 610.0$, $p = .74$).

[6] Other possible computations of the number of frequently used strategies would also be explored, like including the strategies for which student had reported to use it 'sometimes'(3), but such computations did not lead to noteworthy different test results.

Corrections

The first step towards the MLRA models in hypotheses 1 and 2 was to investigate differences that would have to be corrected for: the correlation table in Appendix A includes some variables that were suspected to possibly influence achievement, such as age; previous musical studies; years playing the instrument; years performing with the instrument; and followed courses in effective practicing. Study year and years of performing with the instrument appeared to correlate significantly with the exam grades. This was rather unexpected: of all variables, years of performance experience with the instrument had the strongest correlation with achievement, more than years of practicing the instrument, or any other measure included in this study. Study year and performance experience were inserted in an initial MLRA model as predictors of exam grade ($-2LL_{\text{final model}}$ = 156.095, χ^2 = 13.456, $p < .01$, Nagelkerke R^2 = .155). In this model, performing experience was not as significant ($-2LL_{\text{reduced model}}$ = 161.064, χ^2 =4.969, p = .083) as study year was ($-2LL_{\text{reduced model}}$ = 162.279, χ^2 = 6.183, $p < .05$). To limit the number of predictors in the models, only study year was included to correct for possible interference effects in the following analyses. In a model with only study year as predictor (-2LL = 40.892, Chi = 9.217, p < .01, Nagelkerke R^2 = .108), the effect of study year on the exam grade was statistically significant in the comparison of the low group with the middle group, and the low group with the high group (Low group (reference) -> Middle group: B = .334, Wald $\chi^2(1)$ = 5.509, OR = 1.396, $p < .05$; Low group(ref.) -> High group: B = .416, Wald $\chi^2(1)$ = 7.137, OR = 1.515, $p < .001$). In both effects, the B- coefficient was positive, meaning that a higher study year would enlarge the chance for a case to be in the higher achieving group. This effect was not apparent in the comparison between the middle group and high group (Middle group (ref.) -> High group: B = .082, Wald $\chi^2(1)$ = . 346, OR = 1.086, p = .556).

A Kruskal-Wallis test also revealed a difference in achievement between musical departments ($\chi^2(2)$ = 14.13, $p < .005$). On further inspection, classical and early music students did not differ (classical music: M = 8.00, Mdn = 8; early music: M =7.73 , Mdn = 8), but the jazz-students in the sample had lower exam grades than the others (M = 7.00, Mdn= 7). Classical and early music students were merged into one classical group, because of the small number of early music students (n = 13) and the relative similarity of the departments. A Mann-Whitney U-test comparing the exam grades of the resulting classical group and the jazz students was significant (U = 432.0, Z = -3.70, $p <$ .001). The sizes of middle and high achievement groups were however not large enough in the jazz department to introduce this variable as correction predictor in MLRA models ($n_{\text{jazz-low}}$ = 14, $n_{\text{jazz-middle}}$ = 8, $n_{\text{jazz-high}}$ = 2). This difference between jazz and classical music, and its possible effect on the results, is addressed further in the end of the results section.

Hypothesis 1: Practice time and formal practice

1a. Practice time

In line with hypothesis 1a, practice time did not correlate significantly with achievement, as displayed in the correlation table in Appendix A. In a MLRA model, together with study year as predictor for correction, practice time was not a significant additional predictor of achievement ($-2LL_{\text{final model}} = 162.264$, $-2LL_{\text{reduced model}} = 164.156$, $\chi^2(2) = 1.892$, $p = .388$). Results of the effect of practice time on the comparison of low, middle and high achievement groups are displayed in table 2. The results do not suggest a linear pattern for the effect of practice time on achievement: a positive *B* means that an increase of the predictor variable enlarges the chance to be in the alternative category instead of the reference category. Comparing the low and middle group, a higher amount of practice time would decrease the chance to be in the middle group, as the coefficient is negative, but comparing the middle with the high group, the coefficient is positive. Practice time is the least different between the lowest and the highest group, as the coefficient is close to zero.

Table 2. MLRA model of daily practice time predicting 'Low', 'Middle' and 'High' achievement.

	Compared categories	***B***	**Wald χ^2**	**(df)**	***p***	**Odds Ratio**
Practice time	Low -> Middle	-.279	1.170	(1)	.279	.757
	Low -> High	.064	.055	(1)	.815	1.505
	Middle -> High	.343	1.494	(1)	.222	1.409

Note. Every first-mentioned category is the reference category. Study year was included in the tested model, but only for correcting purposes. It did not behave in a noteworthy different way from its original description as only predictor in a model, so it is excluded from this table.

1b. Formal practice

To test hypothesis 1b, concerning the effects of formal practice characteristics on achievement, the computed variables 'goal-driven practice' and 'focus' were entered as predictors of achievement in a MLRA model, again together with study year as predictor for correction. Both the variables 'goal- driven practice' and 'focus' were not a significant addition to the model (Final Model: $-2LL_{\text{Final Model}} = 172.965$, $\chi^2(6) = 12.180$, $p = .058$, Nagelkerke $R^2 = .140$; 'Goal-driven practice': $-2LL_{\text{reduced model}} = 175.558$, $\chi^2(2) = 2.594$, $p = .273$; 'Focus': $-2LL_{\text{reduced model}} = 173.122$, $\chi^2(2) = .157$, $p = .924$). Table 3 displays the regression coefficients for both computed formal practice variables. The largest effect is contrary to the expected: for the effect of 'goal-driven practice' in comparing the low and middle group, the coefficient is negative ($B = -.382$), meaning that more reported use of goals would decrease the chance on a higher grade for people in the lower group, and increase the chance on a lower grade for people in the middle group.

Table 3. MLRA model of formal practice predicting 'Low', 'Middle' and 'High' achievement.

Predictor	Compared categories	*B*	Wald χ^2	(df)	*p*	Odds Ratio
'Goal-driven practice' (standardized)	Low -> Middle	-.382	2.185	(1)	.139	.682
	Low -> High	-.070	.057	(1)	.811	.933
	Middle -> High	.313	1.275	(1)	.259	1.367
'Focus' (standardized)	Low -> Middle	-.092	.129	(1)	.719	.912
	Low -> High	-.008	.001	(1)	.977	.992
	Middle -> High	.083	.092	(1)	.762	1.087

Note. Every first-mentioned category is the reference category. Study year was included in the tested model, but only for correcting purposes. It did not behave in a noteworthy different way from its original description as only predictor in a model, so it is excluded from this table.

1c. Time x formal practice

To evaluate a possible interaction between practice time and formal practice characteristics, a MLRA model was tested with practice time; practice time in interaction with 'goal-driven practice'; and practice time in interaction with 'focus' as predictors of achievement. Study year was again added as predictor for correction. This model was also not successful (Final Model: $-2LL_{\text{Final Model}}$ = 186.135, $\chi^2(8) = 13.683$, $p = .090$, Nagelkerke $R^2 = .156$; Practice Time: $-2LL_{\text{reduced model}} = 187.956$, $\chi^2(2) = 1.821$, $p = .402$; Practice Time *'Goal-driven practice': $-2LL_{\text{reduced model}} = 187.927$, $\chi^2(2) = 1.792$, $p = .408$; Practice time *'Focus': $-2LL_{\text{reduced model}} = 186.816$, $\chi^2(2) = .681$, $p = .711$). On the level of regression coefficients, the smallest *p*-value ($p = .207$) was found for the interaction of goal-driven practice and practice time, in the comparison of the low (reference) with the middle group (B = .293). All other p- values on hypothesized effects were at least as large as $p = .247$.

Hypothesis 2: Practice strategies

Hypothesis 2a. Specific practice strategies and number of strategies

Hypothesis 2a concerned the possible benefit of using more different practice strategies, rather than a benefit for any strategy in itself. Indeed, no significant correlations were found between achievement and any of the eleven specific strategies, as displayed in table 4. Three negative correlations between strategies and exam grades were closer to significance than the others, although the $\alpha = 0{,}05$ value should be corrected conservatively in case of eleven simultaneous tests. The two most prominent correlations with achievement were for the variables "I repeat the whole piece" and "I try to repeat a short section until I can play it". Random practice distinguished itself from the others, as its negative correlation with achievement was almost as significant as the two aforementioned items, but was reported by students far less than any other strategy. These effects are considered further in the discussion section. 31 students reported additional strategies, next to the presented list. On inspection, all of these strategies seemed unique or comparable to only one or two other reported additional strategies.

Table 4. Spearman correlations between exam grade and practice strategies, and percentages of students that report to use a strategy frequently.

Strategy	ρ	*p*	Frequent users
1. I vary technical aspects (rhythm, dynamics, articulation, key) of the motive.	.128	.215	66 %
2. I vary the interpretation/ musical aspects of the motive.	-.101	.332	46 %
3. I slow the music down	.120	.248	82 %
4. I repeat the whole piece	-.195	.059	37 %
5. I try to repeat a short section until I can play it	-.189	.066	80 %
6. I gesture/sing the music in the way I want to play it.	.021	.843	61 %
7. Random practice: I repeat motives not after each other but mixed through each other. Not: a.a.a. b.b.b. c.c.c. But: a.c.b. c.a.b. a.b.c.	-.184	.075	13 %
8. Whole-part-whole: I play through a piece, practice something that was difficult, and then play a bigger part again.	.033	.753	60 %
9. Chaining: I first play the first notes of a motive and then add notes one by one. (12-123-1234-12345-etc.)	.004	.972	35 %
10. Chunking: I first practice things separately(hands, tongue, left hand and bow, parts of a sentence) and then put them together.	.100	.335	34 %
11. I record myself and listen/watch it.	.109	.296	33 %

Note. Smallest N = 94. All *p*-values are two-tailed. The column 'Frequent users' represents the percentages of students that reported to use a given strategy either often or very often.

Against the hypothesis, the computed number of frequently used strategies did not correlate with exam grade either (ρ = 0,071; *p* = 0,496). Placed in a MLRA model as predictor of achievement, (again including study year as extra predictor), this reported number of strategies was not significant (Final Model: $-2LL_{\text{Final Model}} = 127.361$, $\chi^2(4) = 12.713$, $p > .05$, Nagelkerke $R^2 = .146$; Number of strategies: $-2LL_{\text{reduced model}} = 130.857$, $\chi^2(2) = 3.496$, $p = .174$). One effect is noteworthy, however: The coefficient on the difference between the middle and high group was almost significant and positive, meaning that more strategies could be related to more chance on a higher exam result ($B = .533$, Wald $\chi^2(1) = 3.286$, $p = .070$, OR = 1.703). The coefficient in comparing the low with the high group was even weaker, but also positive ($B = .445$, Wald $\chi^2(1) = 1.434$, $p = .214$, OR = 1.434). An effect in the comparison of the low and middle group was virtually absent ($B = -.172$, Wald $\chi^2(1) = .435$, $p = .510$, OR = .842).

Hypothesis 2b. Number of strategies x formal practice

The correlation table in Appendix A shows a positive and significant correlation between the number of frequently used practice strategies and the computed measure of students' 'goal-driven practice': students with more goal-directed practice behavior also have more strategies at hand, and vice versa.

Support for hypothesis 2b, concerning the effect of the interaction between formal practice and number of practice strategies on achievement could however not be found. A MLRA model predicting achievement included the following covariates (next to study year): 'Number of strategies'; the interaction of the number of strategies with 'goal-driven practice'; and the interaction of the number of strategies with 'focus'. Just as the number of strategies, the interaction effects were not significant (Final Model: $-2LL_{\text{Final Model}} = 180.186$, $\chi^2(8) = 18.247$, $p = .019$, Nagelkerke $R^2 = .203$; Number of strategies * 'Goal-driven practice': $-2LL_{\text{Reduced Model}} = 183.725$, $\chi^2(2) = 3.539$, $p = .170$; Number of strategies *'Focus': $-2LL_{\text{Reduced Model}} = 182.327$, $\chi^2(2) = 2.141$, $p = .343$)). Details of the model are displayed in table 5. Most noteworthy is the pattern that all effects in the comparisons between groups are in the opposite direction when the number of strategies interacts with a formal practice variable, opposed to the effects of the number of strategies alone.

Table 5. MLRA model of strategies interacting with formal practice variables in the prediction of 'Low', 'Middle' and 'High' achievement.

	Compared categories	***B***	**Wald χ^2**	**(df)**	***p***	**Odds Ratio**
Number of strategies (standardized)	Low -> Middle	-.154	.313	(1)	.576	.857
	Low -> High	.306	.800	(1)	.371	1.358
	Middle -> High	.469	1.879	(1)	.170	1.583
Strategies * 'Goals' (standardized)	Low -> Middle	.431	2.267	(1)	.132	1.540
	Low -> High	-.059	.029	(1)	.865	.943
	Middle -> High	-.490	2.130	(1)	.144	.612
Strategies * 'Focus' (standardized)	Low -> Middle	.274	.740	(1)	.390	1.315
	Low -> High	-.219	.342	(1)	.522	.803
	Middle -> High	-.493	1.957	(1)	.162	.611

Note. Every first-mentioned category is the reference category. Study year was included in the tested model, but only for correcting purposes. It did not behave in a noteworthy different way from its original description as only predictor in a model, so it is excluded from this table.

Hypothesis 3: Comparing beginning and advanced students

For the comparison of students over different course years, two new groups were formed: students in the first year of the Bachelor courses formed a group of 'Beginners'(n = 38), and students in the Master courses were entitled as 'Advanced'(n = 31)[7]. As can be seen in table 6, reports of students in the first year and in the Master course were virtually the same, except for years of practicing and performing with the instrument, and two non-significant trends: exam grades appeared to be slightly higher for the advanced students, in line with the preliminary findings that were mentioned in the 'correction' section. Also the number of reported strategies seemed slightly lower for the advanced than for the beginning students.

Table 6. Several comparisons between first-year Bachelor students and Master students.

	Mean (S.D.)		**Median**		**Test**	
	Beginners	**Advanced**	**Beginners**	**Advanced**	**Statistic**	***p***
Exam grade	7.49 (.97)	7.86 (1.06)	7.00	8.00	U = 368.0 Z = - 1.609	.11
Practice time	3.19 (1.69)	3.03 (1.25)	3.00	3.00	t (67) = .46	.65
'Goal-driven practice'	3.87 (.51)	3.72 (.53)	4.00	3.67	t (67) = 1.19	.24
'Focus'	3.25 (.65)	3.27 (.61)	3.33	3.33	t (67) = - .09	.93
Number of strategies	6.66 (2.58)	5.81 (2.04)	7.00	6.00	t (67) = 1.49	.14
Years of practicing	9.46 (4.11)	13.89(3.53)	10.00	14.00	t (67) =- 4.74	<.01
Years of performing	8.80 (4.98)	12.42(3.41)	9.00	12.00	t (66) = - 3.54	<.01

Note. Smallest n(beginners) = 33; smallest n(advanced) = 29. For all t-test comparisons, Levene's test for equality of variances was not significant, except for years of performing experience. All *p*-values are two-tailed.

[7] Only the bachelor students who graduate with a minimal grade of 8 ('good') are generally allowed to do a master's course. In this way the master students could be argued to be a selection of the better bachelor students. Including only the first-year students with a minimal grade of 8 did not lead to noteworthy different results in the comparisons on practice time, goals, focus, or amount of strategies.

Hypothesis 4: Comparing jazz and classical music students

Hypothesis 4a. Differences in the presence of several aspects

Table 7 shows comparisons between students in the jazz and classical music department: no differences were found, except on exam grade, practice time, and years practicing the instrument. classical students also tended to have had more years of performance experience, but this difference was not significant.

Table 7. Several comparisons between jazz and classical music students.

	Mean (S.D.)		**Median**		**Test**	
	Jazz	**Classical**	**Jazz**	**Classical**	**Statistic**	***p***
Exam grade	7.00 (1.02)	8.01 (.91)	7.00	8.00	U = 350.50 Z = - 3.761	<.001
Practice time	3.33 (1.40)	2.68 (1.40)	3.00	2.50	t (103) = 2.11	<.05
'Goal-driven practice'	3.68 (.51)	3.77 (.54)	3.67	3.75	t (103) = - .75	.46
'Focus'	3.36 (.67)	3.30 (.60)	3.33	3.33	t (103) = .49	.62
Number of strategies	5.62 (2.11)	5.91 (2.29)	6.00	6.00	U = 1042.5 Z = - .432	.67
Study year	2.46 (2.05)	2.86 (1.90)	1.00	2.00	U = 922.0 Z = - .1.068	.29
Years of practicing	9.59 (4.11)	12.19(4.20)	9.00	12.00	t (103) = -2.86	<.01
Years of performing	9.24 (4.02)	10.77(4.68)	9.00	11.00	t (102) = -1.55	.13

Note. For all t-test comparisons, Levene's test for equality of variances was not significant. All p-values are two-tailed. $24 \leq n(jazz) \leq 29$, $60 \leq n(classical) \leq 76$.

Hypothesis 4b. Differences in the effect of aspects on achievement

To consider the possibly different effects of formal practice and other variables on achievement for jazz opposed to classical students, correlations were calculated between students' exam grades and practice time, 'goal-driven practice', 'focus', number of strategies, study year, previous musical studies, years practicing the instrument, years performing with the instrument, and followed courses in practicing. Most correlations for the separate departments were comparable to each other and to those in the total sample (Appendix A): In the classical sub-sample, the only significant correlations were found between study year ($\rho = .341$, $p < .01$) and years performing with the instrument ($\rho = .271$, $p < .05$). The smallest p-value of the other correlations in the classical group was found between exam grade and years practicing the instrument ($\rho = .201$, $p = .124$). In the jazz group, no correlation between exam grade and any other variable was significant, as all p-values were equal to or larger than .379.

Sensitivity check for the MLRA models

The results for this fourth hypothesis on jazz and classical music readdress a correction that was mentioned but could not be made in the MLRA analyses: the apparent difference in exam grade between jazz and classical music students was not involved in the MLRA models because of the small number of jazz students in the low and high achievement groups. To gain insight in the sensitivity of the results for the difference in grade between jazz and classical music, a MLRA model from one of the first hypotheses was tested again: this time predicting a measure of exam grades in which the difference between departments was corrected. This new measure, from now on called within-group achievement, was computed as a student's exam grade minus the mean grade of their department (classical, jazz, or early music). A positive within-group achievement score means that the student received a higher grade than the average of that department, while a negative score on this scale says that a student received a lower grade than the department's average. Parameters of this new scale were: M = .01 S.D. = .97, Med. = -.01, Minimum = -2.01, Maximum = 2.27. Like the original exam grades, this new variable did not fit the criteria for a normal distribution. Spearman correlations between these within-group achievement scores and relevant variables revealed a pattern similar to those with exam grade (table C): the within-group achievement scores only correlated significantly with study year (ρ = .226, $p > .05$), and close to significance with years performing with the instrument (ρ = .184, $p = .076$). All other *p*-values were equal to or larger than .183.

In order to run a MLRA test with this alternative department-corrected measure of achievement as dependent variable, the sample was again divided into three alternative groups of comparable size: cut points were based upon the resulting number of students and the balance of students of the different departments in every group: the alternative low group (n = 35) consisted of those with a within-group achievement score lower than -.50; the alternative high group (n = 29) consisted of those with a score higher than .53; the alternative middle group (n = 31) was formed from the students with a score between the given values. With this division, the low group had 45.8 percent of the students from the jazz department, 33.3 percent of the classical students, and 36.4 percent of the early music students; the middle group had 20.8 percent of the jazz students, 36.7 percent of the classical students, and 36.4 percent of the students from the early department; the high group consisted of the remaining 33.3 percent of the jazz students, 30.0 percent of the students in the classical department and 27.3 percent of the early music students.

The MLRA model from hypothesis 1b, concerning the effect of the formal practice variables 'goal-driven practice' and 'focus', was tested once again, but now with the corrected measure of exam performance as dependent variable. The model predicting the department-corrected measure of achievement was comparable to the initial model (Final Model: $-2LL_{\text{Final Model}} = 180.158$, $\chi^2(6) =$

6.778, p = .342, Nagelkerke R^2= .080; 'Goal-driven practice': -2LL $_{reduced\ model}$ = 182.807, χ^2 (2) = 2.649, p = .266; 'Focus': -2LL $_{reduced\ model}$ = 180.369, χ^2 (2) = .211, p = .900): as can be seen in table 8, the effects of 'goal-driven practice' and 'focus' in the specific comparisons of the low, middle and high achievement groups are also comparable to those in the initial model (table 3).

Table 8. Alternative MLRA model of formal practice predicting 'Low', 'Middle' and 'High' achievement, with corrections for achievement differences between departments.

Predictor	Compared categories	*B*	Wald χ^2	(df)	*p*	Odds Ratio
Goal-driven	Low -> Middle	-.413	2.447	(1)	.118	.662
practice	Low -> High	-.125	.216	(1)	.642	.882
(standardized)	Middle -> High	.288	1.152	(1)	.283	1.334
Focus	Low -> Middle	.056	.047	(1)	.829	1.058
(standardized)	Low -> High	.121	.210	(1)	.647	1.128
	Middle -> High	.064	.056	(1)	.812	1.066

Note. Every first-mentioned category is the reference category. Study year was included in the tested model, but only for correcting purposes. It did not behave in a noteworthy different way from its original description as only predictor in a model, so it is excluded from this table.

Discussion

This thesis in applied cognitive psychology was meant to replicate and relate several findings from earlier research in the field of professional musical practice behavior. Students were questioned about several aspects of their practice behavior that were expected to influence achievement. This was done in the period leading up to yearly exam-performances of which the grades were compared to their answers. Several other characteristics were involved too, like study year and musical department.

Practice time and formal practice

As expected, students' daily practice time was not related to achievement. This could be argued to possibly be a consequence of a relatively small sample size (n = 95) causing less statistical power. However, the effects of practice time in the comparisons of 'low', 'middle' and 'high' achievers followed an inconsistent pattern, supporting the notion of no structural relation. Contrary to the expectation, the newly formed formal practice variables 'goal-driven practice' and 'focus' were not significant as predictors of exam grade in a MLRA model. The hypothesized effects of interactions between practice time and these formal practice variables in predicting achievement were also absent. The lack of significance concerning the variables 'goal-driven practice' and 'focus' in relation to achievement, is contrary to the findings of Bonneville-Roussy and Bouffard (2015). This could mean that these newly computed summarizing characteristics of formal practice are not an accurate measure of practice quality. These constructs were formed and interpreted on the basis of their face

validity, construct validity and internal consistency, and consisted of fewer items than the original model. Using the original scales would at least have facilitated better comparisons with previous research. However, including such scales on all the involved topics would expand a survey, making it more difficult to gather information on different relevant topics simultaneously, from a broad sample within a conservatoire. Another possible explanation of the insignificances is that exam grades are not an accurate measure of musical improvement. This is discussed further in the limitations section.

Practice Strategies

There were no significant correlations between specific strategies and achievement, in line with the statement that there are no generally effective learning strategies (Schunk & Zimmerman, 1998). The two strongest, negative, correlations, were found between achievement and "I repeat the whole piece" and "I try to repeat a short section until I can play it". These strategies are often mentioned as basic practice behaviors that people would perform rather automatically (Wulf & Mornell, 2008). The polarity of the third-largest correlation raised doubts about the validity of the item in question: "Random practice: I repeat motives not after each other but mixed through each other." The correlation of this item was as relatively prominent and negative as the aforementioned 'basic' strategies, compared to all the other strategies. But this strategy was by far not reported as much as any of the other strategies. The used formulation of 'random practice' was perhaps not interpreted by students as a deliberate use of some 'desired difficulty' to enhance learning (Bjork, 1994; Schmidt & Bjork, 1998), but more as practicing material 'at random'.

The number of frequently used strategies was not a statistically significant predictor of achievement in the general MLRA model, but having more strategies was almost significantly associated with an increased chance to be in the high achievement group instead of the middle. This is seen as some numerical support for the relevance of having a large set of frequently used strategies. The results of a MLRA model predicting achievement through the interactions of the number of strategies with formal practice characteristics were however rather puzzling. For example: the main effects of 'goal-driven practice' and the number of strategies both had a *negative* coefficient in the comparison of the low and middle group, meaning that more strategies or use of goals would lower the likelihood of a grade in the middle instead of the lower group. The interaction effect of 'goal-driven practice' with the number of strategies was *positive*. Contrarily, in the other comparisons in table 5 (middle and high achievement, low and high achievement) the main effect of strategies was *positive*, while the interaction effects were all *negative*. Some of these interaction effects were relatively large, but their polarities are interpreted as a mathematical consequence of multiplying positive and negative main effects, rather than to behave in a theoretically valid pattern.

At least, a relatively strong positive correlation between the number of frequently used strategies and the computed summarizing variable 'goal-driven practice' provides some support for the notion in the introduction that a set of differently effective practice strategies can be applied on the moment that they are specifically useful. Students with more strategies tend to apply these within a goal-driven practice routine. Or differently: students who make more use of goals to guide their practice behavior, tend to apply more different strategies in this goal-driven practice. Future research could further investigate how students determine such goals; how they choose to apply strategies; to what extent, and in what way, students match goals and practice strategies; and especially how we could train students to set accurate goals and choose matching strategies. For example, it would be interesting to develop experimental research on the possible benefit of training musicians to choose strategies in accordance with cognitive load theory, as illustrated in the theoretical introduction.

Comparing beginners and advanced students

No significant differences were found between students in the first year of the bachelor and advanced students in the master, in terms of practice time, goal-driven practice, focus and number of frequently used strategies. This suggests an absence of improvement on these variables throughout students' education at the conservatoire. Yet, this comparison could be biased in several ways. For example, master students did not necessarily follow their bachelor course at the same conservatoire. Despite considerable effort there was no sufficient number of third- and fourth-year bachelor students in this sample to use their results for testing this hypothesis. Even if the sample would have contained enough students from the later years of the bachelor, we should remain cautious when comparing different groups of students in order to evaluate the development of students over the course of their studies. Future research should especially aim for longitudinal methods, in order to make firmer claims on the development of practice behavior of students through their education to become a professional musician.

Comparing classical and jazz students

Differences between jazz and classical music students on formal practice characteristics were also not found. These results coincide with the claim of Bonneville- Roussy and Bouffard (2015) that jazz- and classical musicians do not differ in the use of formal practice. However, they did find a significant effect of formal practice on achievement in a sample including both jazz and classical musicians, while in the current study both groups were lacking significant relationships between achievement and formal practice: no correlations between exam grade and practice time, goal-driven practice, focus, or amount of strategies were found in the jazz or classical group. The best way

to further investigate possibly different effects of formal practice for jazz and classical music students would have been a MLRA model predicting performance through the interaction of musical department and formal practice variables. Because of the small number of jazz students in the sample, this was unfortunately not possible.

Limitations

Exam grade as measure of achievement

This study especially raises strong concerns about using graded exam performances as measure of musical achievement. Such exam grades have also been used in other studies, but with different grading systems (Bonneville-Roussy, & Bouffard, 2015; Burwell & Shipton, 2011; Jørgensen, 2002). Concerns about the use of grades in this study are based on the small dispersion of grades, and the influence of musical department, study year and performing experience on the height of the grades.

Normally, one could expect a small proportion of randomly chosen students to perform insufficiently. The 95 accessed exam grades from the 118 participants were all '6' or higher, meaning that all these students were judged to perform at least sufficiently. The 23 participants of whom the grade was unknown could contain those who would perform insufficiently. One could however think of many reasons not to fill in a student number, or not play a graded exam performance. Besides, these students did not differ from the others in terms of practice time, goal-driven practice, focus, or number of frequently used strategies. In any way, with a range of only 'sufficient' grades, the spreading of achievement was perhaps not large enough to find convincing differences.

Also, students in the jazz department received lower grades than students in the classical department. The fact that most students in the jazz department were in the low achievement group, could have been a source of bias in the analyses. The numbers of jazz students in the middle and high achieving groups were however not large enough to structurally include the students' department as correcting predictor in the MLRA models. Some insight on this possible influence was gained afterwards: one of the MLRA models was tested again, but now with three alternative low, middle and high achievement groups, based upon students' performance compared to the other students in their department. This did not lead to different results than the model with the original grades, suggesting that the difference in exam grade between jazz and classical music has not been a source of bias. This was however only checked with one of many possible ways to correct for the difference between departments. With a small sample in which the pattern of distribution of the dependent variable was difficult to trace, a thorough investigation on possible corrections was not in in the scope of this thesis.

The difference between jazz and classical students was however not the only surprising predictor of exam grade. Throughout the analyses, students' exam grades appeared to be most associated with study year and performance experience. Students in higher years were more likely to receive a higher grade on the exam for that year. In a normal grading system, the difficulty of an exam should grow with the abilities of students through the years, meaning that the central parameters of comparable exam grades in different years should hypothetically be the same. Especially the number of years of performing experience was significantly correlated with performance on the exam, rather than the number of years that a student practices the instrument. This may mean that such an exam grade could be more a measure of being able to perform well under the pressure of a concert setting -for example how to cope with nervousness (Buma, Bakker, & Oudejans, 2015; Oudejans, Spitse, Kralt, & Bakker, 2017; Yoshie et al., 2009) - instead of an indication of the improvement of musical skill. For a conservatory, this is not necessarily a problem, because the actual concert performance could be argued as the major goal of a course at a conservatoire. Scientists and conservatoires should however be more cautious with interpreting such exam grades as measures of advancement in musical and technical skill.

More limitations

Overall, the sample was perhaps too diverse, or too small for its diversity: Many factors get involved when measuring students of all kinds in a conservatoire, like the instrument, main instrument teacher, culture of origin, and musical department. All these could raise the variance in measurements and influence relations. With a higher number of participants, a larger number of main- and interaction effects could be included simultaneously in the MLRA models.

Investigating aspects of individual behavior like practice time, goal-driven practice, focus, and use of strategies through self-reports remains a possible source of bias. Self-reports have been used successfully in numerous previous studies (Bonneville-Roussy & Bouffard, 2015, Ericsson et al., 1993; Jørgensen, 2002; Nielsen, 2004; Sloboda et al., 1996). However, students do not always seem to judge their own learning effectiveness accurately in all circumstances (Kornell & Bjork, 2008; Kornell et al., 2010; Miksza, 2007; Miksza, 2015). Future research should match self-reports and forms of observation to investigate the validity of self-reports to measure individual practice behavior.

Although the survey was spread in the period leading up to the exams of which the grades were used in the analyses, causal suggestions should - as always - be handled with some caution. For example: two practice strategies that could be considered 'basic' were negatively correlated with achievement, while some positive relation was found between the number of strategies and achievement. This could mean that students who use more strategies perform better, but

alternatively, more skilled students are perhaps better able to use more different strategies. (Quasi-) Experimental methods could lead to firmer interpretation in the future.

Conclusion

This thesis gathered information on many different aspects of professional musical practice behavior, and its development throughout the students' conservatoire education. The results of this study can in some aspects be seen as inconclusive: many expected effects of practice time, formal practice, amount of frequently used strategies, and interactions of these aspects on musical achievement were not found. There is however reason to believe that this is not (or not only) because of an absent relation between those concepts and musical achievement: Especially exam grades should be interpreted with caution, as they may say more about performance abilities than about musical abilities.

The topics included in this thesis were seen as elementary, and the practical report in Appendix D superficially addresses even more topics, like motivation and social factors. But, people could argue for the inclusion of topics like flow, passion, scaffolding, self-efficacy, mental practice, and many others (Bonneville-Roussy, Lavigne, & Vallerand, 2011; Cahn, 2008; Miksza; 2015). During this thesis project, Wulf and Lewthwaite (2016) also published their OPTIMAL theory of motor learning that is definitively useful to understand several different determinants of successful learning within one framework. Any other conservatoire or researcher with the wish to investigate the practice behavior of students, should specifically reconsider what aspects are important to investigate, and how large a questionnaire could be. Like research in many fields, aims of future research on musical practice behavior should regard different aspects: we strive to validate frameworks that include, relate and nuance as many relevant topics as possible and remain applicable in real life. Meanwhile, we should combine self-reports with observations, compare existing scales with new and more concise measures, and aim for longitudinal and experimental methods.

References

Altenmüller, E. (2008). Neurology of musical performance. *Clinical Medicine, 8*(4), 410-413. doi:10.7861/clinmedicine.8-4-410

Araújo, M. V. (2016). Measuring self-regulated practice behaviours in highly skilled musicians. *Psychology of Music, 44*(2), 278- 292. doi:10.1177/0305735614567554

Avanzino, L., Giannini, A., Tacchino, A., Pelosin, E., Ruggeri, P., & Bove, M. (2009). Motor imagery influences the execution of repetitive finger opposition movements. *Neuroscience Letters, 466*, 11-15. doi:10.1016/j.neulet.2009.09.036

Bernardi, N. F., De Buglio, M., Trimarchi, P. D., Chielli, A., & Bricolo, E. (2013). Mental practice promotes motor anticipation: evidence from skilled music performance. *Frontiers in human neuroscience, 7*(451), 1-14. doi:10.3389/fnhum.2013.00451

Bjork, R. A. (1994). Memory and metamemory considerations in the training of human beings. In J. Metcalfe & A. Shimamura (Eds.), *Metacognition: Knowing about knowing* (pp. 185-295). Cambridge, MA: MIT Press.

Bonneville-Roussy, A., Lavigne, G. L., & Vallerand, R. J. (2011). When passion leads to excellence: the case of musicians. *Psychology of Music, 39*(1), 123-138. doi:10.1177/0305735609352441

Bonneville-Roussy, A., & Bouffard, T. (2015). When quantity is not enough: Disentangling the roles of practice time, self-regulation and deliberate practice in musical achievement. *Psychology of Music, 43*(5), 686-704. doi:10.1177/0305735614534910

Boutin, A., & Blandin, Y. (2010). Cognitive underpinnings of contextual interference during motor learning. *Acta psychologica, 135*(2), 233-239. doi:10.1016/j.actpsy.2010.07.004

Buma, L. A., Bakker, F. C., & Oudejans, R. R. (2015). Exploring the thoughts and focus of attention of elite musicians under pressure. *Psychology of Music, 43*(4), 459-472. doi:10.1177/0305735613517285

Burwell, K., & Shipton, M. (2011). Performance studies in practice: an investigation of students' approaches to practice in a university music department. *Music Education Research, 13*(3), 255-271. doi:10.1080/14613808.2011.603041

Cahn, D. (2008). The Effects of Varying Ratios of Physical and Mental Practice, and Task Difficulty on Performance of a Tonal Pattern. *Psychology of Music, 36*(2), 179-191. doi:10.1177/0305735607085011

Donovan, J. J., & Radosevich, D.J. (1999). A meta-analytic review of the distribution of practice effect: Now you see it, now you don't. *Journal of Applied Psychology, 84*(5), 795-805. doi:10.1037//0021-9010.84.5.795

Driskell, J. E., Copper, C., & Moran, A. (1994). Does mental practice enhance performance? *Journal of Applied Psychology, 79*(4), 481-492. doi:10.1037/0021-9010.79.4.481

Ericsson, K., Krampe, R., & Tesch-Römer, C. (1993). The role of deliberate practice in the acquisition of expert performance. *Psychological review, 100*(3), 363-406. doi:10.1037/0033-295x.100.3.363

Evans, P., & Bonneville-Roussy, A. (2015). Self-determined motivation for practice in university music students. *Psychology of Music, 44*(5), 1095–1110. doi:10.1177/0305735615610926

Gabrielsson, A. (2003). Music performance research at the millennium. *Psychology of music, 31*(3), 221-272. doi:10.1177/03057356030313002

Hall, J. C. (2002). Imagery practice and the development of surgical skills. *The American Journal of Surgery, 184*, 465-470. doi:10.1016/s0002-9610(02)01007-3

Hambrick, D. Z., Oswald, F. L., Altmann, E. M., Meinz, E. J., Gobet, F., & Campitelli, G. (2014). Deliberate practice: Is that all it takes to become an expert?. *Intelligence, 45*, 34-45. doi:10.1016/j.intell.2013.04.001

Jørgensen, H. (2002). Instrumental performance expertise and amount of practice among instrumental students in a conservatoire. *Music Education Research, 4*(1), 105-119. doi:10.1080/14613800220119804

Koopman, C., Smit, N., de Vugt, A., Deneer, P., & den Ouden, J. (2007). Focus on practice-relationships between lessons on the primary instrument and individual practice in conservatoire education. *Music Education Research, 9*(3), 373-397. doi:10.1080/14613800701587738

Kornell, N., & Bjork, R. A. (2008). Learning concepts and categories is spacing the "enemy of induction"?. *Psychological science, 19*(6), 585-592. doi:10.1111/j.1467-9280.2008.02127.x

Kornell, N., Castel, A. D., Eich, T. S., & Bjork, R. A. (2010). Spacing as the friend of both memory and induction in young and older adults. Psychology and Aging, 25, 498-503. doi:10.1037/a0017807

Küpers, E., van Dijk, M., McPherson, G., & van Geert, P. (2014). A dynamic model that links skill acquisition with self-determination in instrumental music lessons. *Musicae Scientiae, 18*(1), 17-34. doi:10.1177/1029864913499181

Lehmann, A. C., & Ericsson, K. A. (1997). Research on expert performance and deliberate practice: Implications for the education of amateur musicians and music students. *Psychomusicology: A Journal of Research in Music Cognition, 16*(1-2), 40. doi:10.1037/h0094068

Limb, C. J., & Braun, A. R. (2008). Neural substrates of spontaneous musical performance: An fMRI study of jazz improvisation. *PLoS one, 3*(2), e1679. doi:10.1371/journal.pone.0001679

McPherson, G. E., Nielsen, S., & Renwick, J. (2013). Self-regulation interventions and the development of music expertise. In H. Bembenutty, T., J. Cleary, & A. Kitsantas (Eds.), *Applications of self-regulated learning across diverse disciplines: A tribute to Barry J. Zimmerman*, (pp. 357-382). Charlotte, NC: IAP.

Miksza, P. (2007). Effective practice: An investigation of observed practice behaviors, self-reported practice habits, and the performance achievement of high school wind players. *Journal of Research in Music Education, 55*(4), 359-375. doi:10.1177/0022429408317513

Miksza, P. (2015). The effect of self-regulation instruction on the performance achievement, musical self-efficacy, and practicing of advanced wind players. *Psychology of Music, 43*(2), 219-243. doi:10.1177/0305735613500832

Münte, T. F., Altenmüller, E., & Jäncke, L. (2002). The musician's brain as a model of neuroplasticity. *Nature Reviews Neuroscience, 3*(6), 473-478. Retrieved from http://www.nature.com.ezproxy.leidenuniv.nl:2048/nrn/journal/v3/n6/full/nrn843.html

Nielsen, S. G. (2004). Strategies and self-efficacy beliefs in instrumental and vocal individual practice: A study of students in higher music education. *Psychology of Music, 32*(4), 418-431. doi:10.1177/0305735604046099

Oudejans, R. R., Spitse, A., Kralt, E., & Bakker, F. C. (2017). Exploring the thoughts and attentional focus of music students under pressure. *Psychology of Music, 45*(2), 216–230. doi:10.1177/0305735616656790

Porter, J. M., & Magill, R. A. (2010). Systematically increasing contextual interference is beneficial for learning sport skills. *Journal of Sports Sciences, 28*(12), 1277-1285. doi:10.1080/02640414.2010.502946

Schmidt, R.A., & Bjork, R.A. (1992). New conceptualizations of practice: Common principles in three paradigms suggest new concepts for training. *Psychological Science, 3*(4), 201-217. doi:10.1111/j.1467-9280.1992.tb00029.x

Schunk, D. H., & Zimmerman, B. J. (Eds.). (1998). *Self-regulated learning: From teaching to self-reflective practice*. NY: Guilford Press.

Spruit, E. N., Band, G. P., Hamming, J. F., & Ridderinkhof, K. R. (2014). Optimal training design for procedural motor skills: a review and application to laparoscopic surgery. *Psychological Research, 78*(6), 878-891. doi:10.1007/s00426-013-0525-5

Sweller, J., van Merrienboer, J.J.G., & Paas, F.G.W.C. (1998). Cognitive architecture and instructional design. *Educational Psychological Review, 10*(3), 251-296. doi:10.1023/a:1022193728205

Sloboda, J. A., Davidson, J. W., Howe, M. J., & Moore, D. G. (1996). The role of practice in the development of performing musicians. *British journal of psychology, 87*(2), 287-309. doi:10.1111/j.2044-8295.1996.tb02591.x

Van Gog, T., Ericsson, K. A., Rikers, R. M., & Paas, F. (2005). Instructional design for advanced learners: Establishing connections between the theoretical frameworks of cognitive load and deliberate practice. *Educational Technology Research and Development, 53*(3), 73-81. doi:10.1007/bf02504799

Varela, W., Abrami, P. C., & Upitis, R. (2016). Self-regulation and music learning: A systematic review. *Psychology of Music, 44*(1), 55-74 . doi:10.1177/0305735614554639

Williamon, A., & Valentine, E. (2000). Quantity and quality of music practice as predictors of performance quality. *British Journal of Psychology, 91*, 353–376. doi:10.1348/000712600161871

Wulf, G., & Lewthwaite, R. (2016). Optimizing performance through intrinsic motivation and attention for learning: The OPTIMAL theory of motor learning. *Psychonomic Bulletin & Review*, 1-33. doi:10.3758/s13423-015-0999-9

Wulf, G., & Mornell, A. (2008). Insights about practice from the perspective of motor learning: a review. *Music Performance Research, 2*, 1-25. Retrieved from http://mpr-online.net/

Wulf, G., Shea, C., & Lewthwaite, R. (2010). Motor skill learning and performance: a review of influential factors. *Medical Education, 44*, 75-84. doi:10.1111/j.1365-2923.2009.03421.x

Yoshie, M., Shigemasu, K., Kudo, K., & Ohtsuki, T. (2009). Effects of state anxiety on music performance: relationship between the Revised Competitive State Anxiety Inventory-2 subscales and piano performance. *Musicae Scientiae, 13*(1), 55-84. doi:10.1177/1029864909013001003

Zhukov, K. (2009). Effective practising: a research perspective. *Australian Journal of Music Education,* (1), 3. Retrieved from http://search.informit.com.au.ezproxy.leidenuniv.nl:2048/search;res=IELHSS;search=FTI=yes%20AND%20IS=0004-9484%20AND%20IRF=1%20AND%20PY=2009%20AND%20PG=3

Zimmerman, B. J. (1998a). Academic studying and the development of personal skill: A self-regulatory perspective. *Educational Psychologist, 33(2-3),* 73-86. doi:10.1080/00461520.1998.9653292

Zimmerman, B. J. (1998b). Developing self-fulfilling cycles of academic regulation: An analysis of exemplary instructional models. In Schunk, D. H., & Zimmerman, B. J. (Eds.), *Self-regulated learning: From teaching to self-reflective practice.* NY: Guilford Press.

Table A. Spearman correlations between hypothetically and possibly relevant variables in the thesis report.

	Exam Grade	Practice Time	Goal-directed practice	Focus	Number of frequently used strategies	Age	Study year	Previous musical studies	Years playing the instrument	Years performing with the instrument
Exam Grade	-									
Practice Time	-.053	-								
Goal-directed practice	-.060	.073	-							
Focus	-.017	-.031	.177	-						
Number of frequently used strategies	.071	.020	.521**	.081	-					
Age	.049	-.006	-.049	-.092	-.038	-				
Study year	.227*	-.040	-.124	-.011	-.116	.658 **	-			
Previous musical studies	-.087	.012	.115	-.007	.135	.248 **	.112	-		
Years playing the instrument	.177	-.139	.073	-.083	-.102	.231 *	.423**	-.122	-	
Years performing with the instrument	.282**	-.028	.132	-.013	.001	.271 **	.344**	-.021	.762**	-
Followed courses in practicing	.076	-.124	-.056	-.046	-.088	.240 **	.283**	-.028	.262**	.334**

Note. Significant correlations are marked: * is a significance on the 0.05 level (two-tailed), ** means significance on the 0.01 level (two-tailed)). Smallest N = 92.

Appendix B: Overview of variables

Table B. Variable overview for the total sample and the low, middle and high achievement groups

		Mean	S.D.	Minimum	Median	Maximum	N
Exam grade	**Total**	**7.71**	**1.04**	**6.0**	**8.0**	**10.0**	**95**
	Low	6.57	.50	6.0	7.0	7.0	35
	Middle	7.93	.18	7.5	8.0	8.0	36
	High	9.06	.34	8.5	9.0	10.0	24
Practice time (Hours: Minutes)	**Total**	**2:50**	**1:27**	**0:00**	**2:50**	**7:00**	**118**
	Low	3:02	1:31	0:10	3:00	6:40	35
	Middle	2:34	1:23	0:00	2:25	6:10	36
	High	3:04	1:31	0:30	3:00	7:00	24
'Goal-driven practice'	**Total**	**3.73**	**.54**	**2.33**	**3.67**	**4.83**	**118**
	Low	3.86	.53	2.50	4.00	4.83	35
	Middle	3.63	.61	2.33	3.67	4.50	36
	High	3.78	.43	2.83	3.67	4.50	24
'Focus'	**Total**	**3.27**	**.62**	**1.67**	**3.33**	**4.67**	**118**
	Low	3.33	.72	1.67	3.33	4.76	35
	Middle	3.24	.56	2.00	3.33	4.33	36
	High	3.31	.60	2.33	3.33	4.33	24
Number of frequently used strategies	**Total**	**5.94**	**2.29**	**1.0**	**6.0**	**14.0**	**118**
	Low	6.17	2.36	2.0	6.0	14.0	35
	Middle	5.56	2.17	1.0	5.0	10.0	36
	High	6.63	2.20	2.0	6.5	11.0	24
Study year	**Total**	**2.83**	**1.92**	**0**	**2**	**6**	**115**
	Low	2.21	1.73	1	1	6	33
	Middle	3.29	1.84	1	3	6	35
	High	3.58	1.96	1	4	6	24
Years playing the instrument	**Total**	**11.32**	**4.44**	**1.5**	**11.0**	**20.0**	**118**
	Low	10.97	4.14	4.0	10.0	19.0	35
	Middle	12.10	4.31	2.0	12.5	20.0	36
	High	12.46	5.17	4.0	12.0	20.0	24
Years performing with the instrument	**Total**	**10.48**	**4.65**	**1.0**	**10.0**	**20.0**	**117**
	Low	9.81	4.86	2.0	9.0	19.0	34
	Middle	10.93	3.61	2.0	10.0	19.0	36
	High	13.09	4.61	4.0	12.5	20.0	24

Note. Study year '0' stands for a preparatory year.

Appendix C: Survey on Practice Behavior in the Royal Conservatoire

This internal survey gathers information on the practice habits of students. It is very important that you are honest to yourself: We want the answer that is **most true about you, not what you think is good**. All your answers will be treated **confidentially**; no-one will know that your answers were yours. In this survey, when we mention practice, we mean **playing alone**, no rehearsals or jam sessions.

Is something **unclear?** Please **ask for help**!

Student Number:_____

*With your student number, we can use your grade in a database, but in a **strictly anonymous** way!*

---

1 Practice time

How many hours per day did you practice **last week**? *Please estimate the amount of hours per day as accurately as possible. Please only report for your main instrument.*

	Yesterday	Two days ago	Three days ago
Hours			

How long are your practice sessions on average? *(Continuous practice, without brakes that are longer than 10/15 minutes)*

_____

How many of such practice sessions do you have per day?

_____

Please fill in: Normally, I take short breaks after _____ minutes practice.

Please tell if you agree:

If I would practice more than I do now, I could be even better.	Totally disagree	Partly Disagree	Neutral	Partly Agree	Totally Agree
I plan my breaks somehow in advance.	Totally disagree	Partly Disagree	Neutral	Partly Agree	Totally Agree
Skipping a day of practice is bad for my learning.	Totally disagree	Partly Disagree	Neutral	Partly Agree	Totally Agree

At the end of a practice session:

My mind is tired	Never	Rarely	Sometimes	Often	Very often
My body is tired	Never	Rarely	Sometimes	Often	Very often
I have pain somewhere	Never	Rarely	Sometimes	Often	Very often

2 Formal practice

When something is difficult, I try to find/make exercises to learn it.	Never	Rarely	Sometimes	Often	Very often
My practice is mainly just playing through the music from beginning to end.	Never	Rarely	Sometimes	Often	Very often
Before I start playing, I think about one specific thing that I want to focus on.	Never	Rarely	Sometimes	Often	Very often
I plan my practice in advance.	Never	Rarely	Sometimes	Often	Very often
When I've set a goal to improve one thing, I stick to evaluating and improving that thing.	Never	Rarely	Sometimes	Often	Very often
During practice, I structurally take moments to think about what I want to improve.	Never	Rarely	Sometimes	Often	Very often
During practice, I often think about something else while I'm playing.	Never	Rarely	Sometimes	Often	Very often
During practice I'm often distracted by things like my phone	Never	Rarely	Sometimes	Often	Very often
I practice only because I have to	Never	Rarely	Sometimes	Often	Very often
I can put myself to practice things that I don't like	Never	Rarely	Sometimes	Often	Very often
I try to practice in a place that doesn't distract me	Never	Rarely	Sometimes	Often	Very often
I try to avoid practicing	Never	Rarely	Sometimes	Often	Very often
When I practice, my thoughts are fully engaged	Never	Rarely	Sometimes	Often	Very often
My practice could be more effective	Never	Rarely	Sometimes	Often	Very often
I know how I could make my practice more effective	Never	Rarely	Sometimes	Often	Very often
I should learn things quicker than I do now	Never	Rarely	Sometimes	Often	Very often
I generally look forward to practicing	Never	Rarely	Sometimes	Often	Very often
I enjoy practicing.	Never	Rarely	Sometimes	Often	Very often

3 Practice strategies

Think about how you practiced yesterday. (If you didn't really practice normally yesterday, take the day before). The following strategies are not good or bad! Please just tell what you did/used.

Metronome	Never	Rarely	Sometimes	Often	Very often
Tuning machine	Never	Rarely	Sometimes	Often	Very often
Before I practice, I do a warmup	Never	Rarely	Sometimes	Often	Very often
I do many technical exercises (scales, arpeggios, etc.)	Never	Rarely	Sometimes	Often	Very often

When I needed to practice a motive last days, I used the following strategies:

I vary technical aspects (rhythm, dynamics, articulation, key) of the motive.	Never	Rarely	Sometimes	Often	Very often
I vary the interpretation/ musical aspects of the motive.	Never	Rarely	Sometimes	Often	Very often
I slow the music down	Never	Rarely	Sometimes	Often	Very often
I repeat the whole piece	Never	Rarely	Sometimes	Often	Very often
I try to repeat a short section until I can play it	Never	Rarely	Sometimes	Often	Very often
I gesture/sing the music in the way I want to play it.	Never	Rarely	Sometimes	Often	Very often
Random practice: I repeat motives not after each other but mixed through each other. For example, Not: a.a.a b.b.b c.c.c, But a.b.c. a.c.b. a.b.a.	Never	Rarely	Sometimes	Often	Very often
Whole-part-whole: I play through a piece, practice something that was difficult, and then play a bigger part again.	Never	Rarely	Sometimes	Often	Very often
Chaining: I first play the first notes of a motive and then add notes one by one. (12-123-1234-12345-etc.)	Never	Rarely	Sometimes	Often	Very often
Chunking: I first practice things separately (hands, tongue, left hand and bow, parts of a sentence) and then put them together.	Never	Rarely	Sometimes	Often	Very often
I record myself and listen/watch it.	Never	Rarely	Sometimes	Often	Very often
I use many strategies frequently.	Totally Disagree	Partly Disagree	Neutral	Partly Agree	Totally Agree
I know why the strategies that I use are effective.	Totally Disagree	Partly Disagree	Neutral	Partly Agree	Totally Agree

- If you use other strategies frequently, please mention them below:

_____

_____

_____

_____

_____

_____

4 Teacher and peers

I talk about practicing with other students.	Never	Rarely	Sometimes	Often	Very often
I practice together with other students.	Never	Rarely	Sometimes	Often	Very often
My teacher doesn't only tell what I should improve, he/she also tells me how I could practice it.	Never	Rarely	Sometimes	Often	Very often
After a lesson from my teacher, I clearly know what I should practice, and how I should do that.	Never	Rarely	Sometimes	Often	Very often
During the week, I practice the things that my teacher told me.	Never	Rarely	Sometimes	Often	Very often
My teacher tells me to practice in a way that doesn't work for me.	Never	Rarely	Sometimes	Often	Very often
My teacher gives me a lot of room for own suggestions and choices (for example in repertoire, interpretation).	Never	Rarely	Sometimes	Often	Very often
I watch videos/ live performances of my instrument	About never	Less than once a week	About once a week	More than once a week	Daily
During my lessons, my teacher plays his/her instrument.	Never	Rarely	When necessary	Much	Too much

- Did you ever follow a course on practicing? Please write them down.

  (For example from Susan Williams or Wieke Karsten, or the Alexander technique)

  _____

  _____

  _____

Personal information

You're almost done, only a few questions about you:

Age: _____ years

Gender: M / F

Bachelor/Master/Different:_____ Year:_____

Instrument:_____

Discipline: Jazz / Classical / Ancient music / Music Education / School of Young Talent / Different

If you did any studies/ had any education before, please write them down below:

_____
_____

How long ago did you start playing your instrument? *(Not sure? Estimate it as good as possible)*

_____years

How many years ago was your first performance? *(Not sure? Estimate it as good as possible)*

_____years

Did you understand the questions?	Totally not	Partly	Most	Almost all	Perfectly

Appendix D

An Overview of Students' Practice Behavior:

a practical report for the Royal Conservatoire

Universiteit Leiden

Koninklijk Conservatorium Royal Conservatoire

Introduction

The Royal Conservatoire is constantly involved in improving its education. Examples include an active Education Committee, the annual Student Satisfaction Survey and other evaluating activities of the Quality Assurance office, but also initiatives like the research groups *Teacher of the 21st Century* and *Research in the Arts*, as well as a successful new staff development program. As a complement to such activities, the current survey serves to evaluate another substantial part of professional music education: individual practice. Daily practice forms a substantial part of the musicians' education, and remains a crucial activity throughout the musical career[1]**.** Therefore, all curriculum descriptions of the instrumental and vocal bachelors at the Royal Conservatoire include a goal concerning independent practice: "*At the completion of their studies, students should have acquired effective practice and rehearsal techniques for improvement through self-study.*"[2] The aim of this report is to evaluate the practice behavior of students, together with some related factors.

This is a practical supplement to an academic thesis report. This supplement includes results that were not included in hypothesis testing in the thesis, yet relevant for the conservatoire. Some of the following results have been discussed in the academic thesis document too. Yet, the following sections lay more emphasis on developing an overview: These sections are descriptive, rather than testing strict hypotheses. They serve to provide insight in the practice behavior of students and some related topics, with the goal to evoke further consideration, discussion and research by teachers and students.

The majority of the topics were introduced during exploratory interviews with numerous specialists in the field of teaching and practicing within the conservatoire. The sections cover the following topics: *practice time* and *breaks*; practice *quality and strategies*; *students' own beliefs* about their practice; *motivation*; and the role of *teachers and peers*. The sections can be read separately, one could start with any section that seems most interesting. Results in each section are accompanied by short explanations of theoretical or practical grounds for considering the topic or questions within it. This report ends with concise conclusions and recommendations. A full description of the methods and analyses that were used in this project can be found in the academic thesis report. The original questionnaire can be found in appendix B. Any further questions about the content of, background for, or methods behind this report, can be sent to jvanketel@hotmail.com.

[1] As Jørgensen (2002) concluded: "If the leaders of an institution are concerned with the institution's study quality, and establish the development of a practice climate based on personal experience and research, illuminated by reflection and curiosity and willingness to try new approaches, then we will find that practice is one of the most important issues to put on the agenda." (p. 117)

[2] Page 5 of the Classical, Jazz and Early Music bachelor curricula (2016-2017).

Sample description

The sample included 118 students, from the bachelor (n= 94) and master (n = 38) courses in the jazz (n = 29), classical (n = 76) and early music (n = 13) departments. Nine students were in a preparatory year. Instruments were merged into seven groups, displayed in table 1. In the analyses, possible differences between departments and instrument groups were checked and, if found, reported too.

Table 1. Frequency distributions for instrument groups, disciplines and courses.

	Jazz		**Classical**		**Early music**		**Total**
Group	bachelor	master	bachelor	master	bachelor	master	
Strings	3	1	19	2	1	2	**28**
Key instruments	2	1	7	3	3	1	**17**
Plucked strings	5	0	4	2	2	0	**13**
Woodwinds	5	5	11	8	1	1	**31**
Brass	0	0	5	5	0	1	**11**
Percussion	5	1	0	0	0	0	**6**
Voice	0	0	8	2	1	0	**11**
Total	**20**	**8**	**54**	**22**	**8**	**5**	**117**

Note: one case from the jazz department did not fill in instrument and course, leading to a lower total number.

Global: practice time and breaks, tiredness and pain

This section discusses some global aspects of practice: The average amount of daily practice, the length of practice sessions, tiredness, and pain after practicing.

Reported practice time was measured as the average of the reported amounts of practice in the past three days displayed as the first question in table 2. Days without practice are included in this mean. Please note that a 25th percentile means that 25 percent of the respondents report below the given number, and 75 percent reports above it. In this context, the median is the 50th percentile: half of the students report below the median, and half of the students report above it.

Table 2. Means and distributions of practice time.

	Mean	Minimum	25th Percentile	Median	75th Percentile	Maximum
Average practice time in the past 3 days (hours: minutes)	*2:52*	0:00	1:50	2:50	3:50	7:00
Session duration (hours: minutes)	*1:19*	0:15	0:45	1:00	1:30	5:30
Daily number of sessions	*3,2*	1	2	3	4	13
'Normally, I take short breaks after '…' minutes of practice'	*43*	10	25	40	60	120

Note: N = 118.

Students were asked how long they practiced without taking a break ('Normally, I take short breaks after '…' minutes of practice'). As can be seen in table 2, 75 percent of the students practiced for at least 25 minutes without taking a break, half of the students didn't take a break in forty minutes, and a quarter practiced for an hour or more, without intermission. This highest quartile did not contain any brass or vocal students, and consisted mainly of keyboard instruments, woodwinds and plucked strings.
As can be seen in table 3, the extent to which students perceive mentally and/or bodily fatigue at the end of a session is reasonable: most students are sometimes or often mentally fatigued, and the majority reports to be physically tired sometimes or often. Specifically, students in the classical department report to be physically tired after a session more often than the early music and jazz department, while on average the classical students have shorter practice sessions than the other departments[3].

Table 3. Relative distributions of reports on fatigue and pain.

	Mean	Never	Rarely	Sometimes	Often	Very often
At the end of a session my mind is tired	*3,4*	1%	9%	46%	37%	8%
At the end of a session my body is tired	*3,2*	2%	16%	50%	23%	9%
At the end of a session I have pain somewhere	*2,4*	15%	47%	22%	15%	2%

Note. Questions are framed on a 5 point scale: Ranging from Never (1), to Very Often (5). The means of these answers lay between 1 and 5: closer to 1 would mean more rejection of the statement; closer to 5 would be more affirmative. Percentages may not add to 100, due to rounded numbers. Smallest N = 117.

Luckily, perceiving pain at the end of a session (last row in table 3) is less common than fatigue, yet 39 percent of the participants report to have pain either sometimes (22 %), often (15 %), or very often (2%). Especially, a relatively large number of woodwind students reported to have pain often (32 % of the woodwind students).

Goals, Focus, and Strategies

More than practice quantity, the content of individual practice time is important. This has been addressed extensively in the academic thesis report, so only a brief overview will be given here. For more information on the roles of quantity and quality of practice I direct to the theoretical introduction of the academic thesis report.

Three measures were computed on the basis of several questions: 'goal-directed practice' during individual practice[4], 'focus' during individual practice[5], and 'number of practice strategies'. 'Goal-directed practice' and 'focus' are summarized in the first two rows of table 4. These variables range from 1 to 5, with 1 being an absence of any goal-directed practice or focus, and 5 being the highest measurable report of goals and focus

[3] Means of the reported practice session durations for each department are: Mean(Jazz) = 1h33min; Mean(Classical) = 1h10min; Mean(Early Music) = 1h 37 min. The means of physical fatigue in different departments are (on a scale from 1 to 5): Mean(Jazz) = 2,9; Mean(Classical) = 3,4; Mean(Early Music) = 3,1.

[4] 'Goal-directed practice' was computed as the mean of responses on the questions: *When something is difficult, I try to find/make exercises to learn it; My practice is mainly just playing through the music from beginning to end (negative); Before I start playing, I think about one specific thing that I want to focus on; I plan my practice in advance; When I've set a goal to improve one thing, I stick to evaluating and improving that thing; During practice, I structurally take moments to think about what I want to improve.*

[5] 'Focus' was computed as the mean of responses on the questions: *During practice, I often think about something else while I'm playing (negative); During practice I'm often distracted by things like my phone (negative); When I practice, my thoughts are fully engaged.*

during individual practice. In this sense, results are mediocre: results on the 25th percentile mean that 75 percent of the students scored above the given score, so we see that at least 75 percent of the students score above 3 on both measures, which is the middle of this scale. However, as the value of 3 initially stood for 'sometimes' and 4 and 5 stood for 'often' and 'very often', goal-directed practice and focus during practice could be improved. Any differences on these variables between instrument groups, departments, and study years are virtually absent[6]. This lack of difference between students in different years suggests an absence of development through the years[7].

Table 4. Means and distributions of answers on questions concerning practice content

			25th		**75th**	
	Mean	**Minimum**	**Percentile**	**Median**	**Percentile**	**Maximum**
Goal-directed practice (on a range from 1 to 5)	*3,7*	2,3	3,3	3,7	4,1	4,8
Focus (range from 1 to 5)	*3,3*	1,7	3	3,3	3,7	4,7
	Mean	**Never**	**Rarely**	**Sometimes**	**Often**	**Very often**
Metronome	*3,3*	5%	18%	33%	26%	18%
Tuner	*2,5*	42%	12%	17%	14%	15%
Before I practice, I do a warmup	*3,8*	3%	17%	17%	19%	44%
I do many technical exercises (scales, arpeggios, etc.)	*3,6*	5%	17%	22%	26%	30%

Note. **A 25th percentile means that 25 percent of the respondents report below the given number, and 75 percent report above it. In this context, the median is the 50th percentile: half of the students report below the median, half of them above it.** Questions were framed on a 5 point scale: Ranging from Never (1), to Very Often (5). The mean answers on these questions lay between 1 and 5: closer to 1 would be more affirmative; closer to 5 would be more rejecting the statement. Percentages may not add to 100, due to rounded numbers. Smallest N = 117

Table 4 also displays some additional practice content aspects: the use of a metronome and tuner, the number of students who do a warmup, and the extent to which students report to do technical exercises. Students differ in their warmups: Less Jazz players do a warmup, compared to Classical and Early Music students[8]. Comparing instruments, students on key instruments and percussion seem to do less warmups, while brass and voice do the most[9]. Also, less students on keyboard instruments or plucked string instruments report to do technical exercises[10].

[6] Kruskal Wallis tests: Differences on 'Goal-directed practice' between departments: χ^2= 0,908, df = 2, p = 0,635. Between instrument groups: χ^2= 2,913, df = 6, p = 0,820. Differences on 'Focus': Between departments: χ^2= 3,044, df = 2, p = 0,218.) . Between instrument groups: χ^2= 3,998, df = 6, p = 0,677.

[7] Spearman correlations between Study Year and respectively 'Goal-directed practice' and 'Focus': ρ = -0,119; p = 0,21; N = 115; ρ = -0,005; p = 0, 96; N = 115. Also see the results and conclusions of the academic thesis (Hypothesis 3).

[8] 35 percent of the jazz students does a warmup either often or very often; for the Classical and Early Music, this is respectively 74 percent and 62 percent.

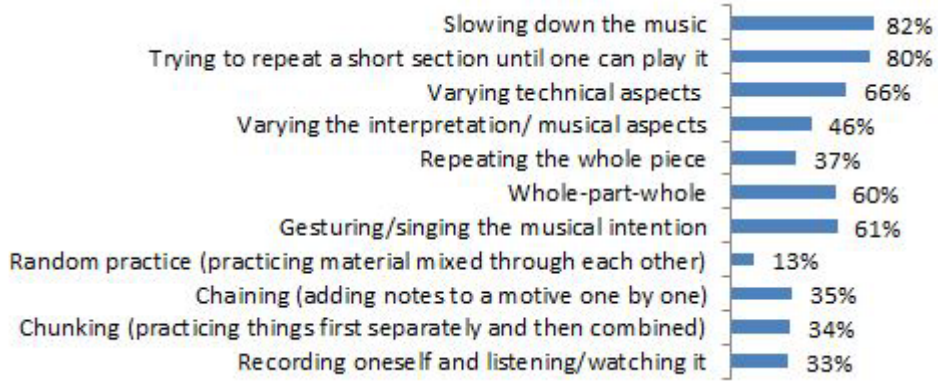
[9] Only 36 percent of the key instrumentalists and 34 percent of the percussionists reported to warmup regularly (often or very often), while 100 percent of the brass players and 91 percent of the singers report to do so.

[10] 59 percent of the students on key instruments, and 46 percent of the students on plucked string instruments never or rarely does technical exercises.

Practice strategies

How to practice music? As described in the academic thesis, there are no better or less effective practice strategies. Rather, different circumstances ask for different strategies: knowing more different strategies, and using them on the moment that they are specifically useful, is beneficial[11]. Students' practice strategies are therefore best summarized by the number of frequently used practice strategies[12]. 13 percent of the students use less than 4 strategies frequently; 47 percent has a frequently used set of 4 to 6 strategies; 42 percent uses 7 to 9 strategies structurally; and the remaining 5 percent reports 10 strategies or more[13].

Figure 1. Percentages of students that use a strategy frequently



Note. The bars display the percentage of students that reported to use a given strategy either often or very often. N = 115.

The responses on several practice strategies are displayed in figure 1. This table displays the percentage of students that reports to use a strategy often or very often. Again, any practice strategy may not necessarily be better or less, almost every strategy can be useful on a given moment[12]. However, this figure does show that some strategies are used more than others: Repeating a short section until the student can play it, and playing in a slower tempo, are the most used strategies. Several other strategies are proven to be useful at times, but not as well-known. Some examples are Random practice, Chaining, and Chunking: *Random practice* is to repeat motives not after each other but mixed through each other (For example, not: a.a.a b.b.b c.c.c, but a.b.c. a.c.b. a.b.a.); *Chaining* means playing the first notes of a motive and then adding notes one by one (12-123-1234-12345-etc.); *Chunking* is to firstly practice things separately (hands, tongue, left hand and bow, parts of a sentence) and then put them together. 31 students also filled in extra strategies that were not included in the presented list. Almost all of these strategies were unique. To conclude, students would benefit from increasing their number of strategies, if different strategies would become more well-known[14].

[11] See the academic thesis ('*It's not about any 'right' strategies*'; hypothesis 2), as well as Schunk and Zimmerman (1998); Williamon and Valentine (2000) and Nielsen (2004)

[12] This number of practice strategies was computed by counting the strategies for which a student had reported to use it 'often' or 'very often'. Students also had the possibility to write down any additional strategies they used frequently, these strategies were also added to this counted number of often used practice strategies.

[13] With a mean of almost 7 strategies (M = 6,9), Early Music students reported to have more frequently used strategies than Classical (M = 5,9) and Jazz (M = 5,6) students. However, because of the small number of Early Music respondents (N = 13), we should be cautious with firm interpretations.

[14] Jørgensen (2002); Nielsen (2004)

Beliefs: what do students think themselves?

This section covers students' beliefs on practicing. An overview is displayed in table 5. It is important to see these subjective beliefs in relation to other measures of practice behavior, and be careful with firm interpretations: from earlier research we know that intuition and experiences can contradict actual learning results[15]. In essence, a person that reports to know exactly what is good, could still either be well informed or naïve.

Table 5. Means and relative distribution of answers concerning students' own beliefs regarding practice

	Mean	Totally Disagree	Partly Disagree	Neutral	Partly Agree	Totally Agree
Skipping a day of practice is bad for my learning	*2,4*	33%	29%	13%	18%	7%
If I would practice more than I do now, I could be even better	*3,9*	2%	11%	14%	47%	26%
I know why the strategies that I use are effective	*4,1*	0%	3%	20%	45%	33%
		Never	**Rarely**	**Sometimes**	**Often**	**Very often**
I should learn things quicker than I do now	*3,0*	5%	23%	45%	24%	3%
My practice could be more effective	*3,6*	0%	4%	50%	31%	14%
I know how I could make my practice more effective	*3,7*	0%	9%	30%	45%	15%

Note. Questions are framed on a 5 point scale: Ranging from Never (1), to Very Often (5), or from Totally Disagree(1) to Totally Agree (5). The means of these answers lay between 1 and 5: closer to 1 would mean more rejection of the statement, closer to 5 would be more affirmative. Percentages may not add to 100, due to rounded numbers. Smallest N = 117.

The reports on the first statement in table 5 show that a substantial number of students (62%) are aware of the fact that skipping a day of practice is not harmful. This may be seen as good news, because skipping a day of practice is indeed claimed not to be harmful[5]. It can even be beneficial for aspects like recovery of muscles and memory consolidation[16].

As can be seen in the responses on the second statement in table 5, many students (73%) partly or totally agree with the idea that they their achievement would benefit from increasing their practice time. A negative correlation with their amount of practice time[17] suggests a certain ability of students to judge their own amount of practice, as those who practice more think less that they should increase their practice and vice versa.

However, as discussed in the academic thesis report and in the previous section, the quality of such practice time is at least as important for development[18]. The last four questions in table 5 give some insight in students' convictions on their practice quality. It is interesting to compare the last two questions: "*My practice could be more effective"*, and "*I know how I could make my practice more effective*". A considerable number of students reports that their practice could be more effective: only 4 percent barely recognizes this, and 45 percent even reports that they could 'often' or 'very often' be more effective. The results on the

[15] Kornell & Bjork (2008); Kornell, Castel, Eich, & Bjork (2010); Schmidt & Bjork (1992)

[16] This was concluded during the *From Potential To Performance* conference at the Royal Conservatoire in 2014, as described in the resulting publication (Williams, 2014).

[17] Spearman correlation between "*If I would practice more than I do now, I could be even better*" and the average practice time of the last three days: $\rho = -0{,}248$; $p < 0{,}01$; N = 118.

[18] Bonneville-Roussy & Bouffard (2015)

question whether they know how to improve their efficiency are about the same[19]. This means that just as many students are convinced of a need of improvement as the number of students that reports to know how to improve. However, these variables did not correlate significantly[20], meaning that those who report that they need improvement are not always the same students as those who say to know how to improve. In other words, some students are convinced that they have enough knowledge to improve their practice effectiveness, while others do not think they have sufficient knowledge to become as effective as they would want to be.

An important additional question in this is: are students correct in their estimation of practice effectiveness? This question is difficult to answer, because practice effectiveness is not measured purely objectively. However, responses on the statement "My practice could be more effective" correlated negatively with the computed practice variables '*goal-directed practice*'[21] and '*focus*'[22]: those who - indirectly- report goal-driven or focused practice are more convinced of the effectiveness of their practice, whereas those who report less goal-directed practice or focus mostly report that their practice could be more effective. This suggests a certain knowledge of the importance of goals and focus, and an ability of students to rate their own practice effectiveness in these terms.

Motivation

The survey also contained four questions to investigate motivation (e.g. *"I practice only because I have to"*; *" I generally look forward to practicing*"), as it is closely related to many other constructs and aspects of the musician's life, according to different specialists within the KC and scientific literature[23]: To muster the effort to practice effectively every day, one requires a considerable amount of motivation.

The answers on the motivation items are summarized in table 6. Both the means and percentages clearly show that the first two - negatively framed - questions received lower ratings than the other two - positively framed - questions. This means that all variables consistently show that most students report to be fairly motivated. Three of these questions were merged into one summarizing variable on 'motivation'[24]. On inspection of this summarizing motivation variable, motivation did not seem to differ structurally between students from different study years, departments, or instrument groups. Motivation correlated significantly with three other variables: it correlated positively with the two formal practice variables '*goal-directed practice*'[25], and '*focus*'[26], and negatively with '*My practice could be more effective*'[27]. This suggests that those who are motivated practice more effectively. However, we cannot infer any causal relations from these results: we don't know if students are more motivated because of their perceived practice skills, or practice better because of a higher amount of motivation.

[19] Results on the items "*My practice could be more effective"* and "*I know how I could make my practice more effective*" do not differ significantly: Wilcoxon signed rank test: Z = -0.99; p = 0.321(two-tailed); N = 117
[20] Spearman correlation: N = 117; ρ = 0,034; p = 0,719 (two-tailed)
[21] Spearman correlation: N = 118; ρ = -0,223; p < 0,05 (two-tailed)
[22] Spearman correlation: N = 118; ρ = -0,439; p < 0,01 (two-tailed)
[23] Evans & Bonneville-Rousy (2015); Küpers, Van Dijk, McPherson, & Van Geert (2014); Zhukov (2009)
[24] Statistics of the new Motivation variable: N = 106; M = 3,8; Mdn = 4. Cronbach's α = 0,709. PCA: Eigenvalue: 1,94; VAF = 64,7%. Including the item "*I try to avoid practicing*" would lead to a lower Cronbach's α and VAF)
[25] Spearman correlation: N = 118; ρ = 0,241; p < 0,01 (two-tailed)
[26] Spearman correlation: N = 118; ρ = 0,368; p < 0,01 (two-tailed)
[27] Spearman correlation: N = 118; ρ = - 0,246; p < 0,01 (two-tailed)

Table 6. Mean answers and relative distribution of answers on motivation questions

	Mean	Never	Rarely	Sometimes	Often	Very often
I practice only because I have to	***2,1***	26%	43%	26%	3%	1%
I try to avoid practicing	***1,7***	47%	40%	12%	2%	0%
I generally look forward to practicing	***3,6***	1%	7%	36%	44%	12%
I enjoy practicing	***4***	0%	1%	22%	52%	26%

Note. Questions are framed on a 5 point scale: Ranging from Never (1), to Very Often (5). The mean answers on these questions lay between 1 and 5: closer to 1 would be more affirmative; closer to 5 would be more rejecting the statement. Percentages may not add to 100, due to rounded numbers. N = 118.

In the context of motivation, one other question is also vital to consider: "I can put myself to practice things I don't like." Not every activity during individual practice may be intrinsically motivating (as to say: nice to do in itself). An important question is then: do students have the discipline to make themselves undertake such actions? Students reported that they could put themselves to practice things they don't like in the following distribution: 3 percent reported 'Never', 12 percent 'Rarely', 32 percent 'sometimes', 44 percent 'often' and 9 percent 'Very often'[28].

Teachers and peers

This last section could also be called: social learning. It considers several social learning matters that influence practice behavior and skill development. First, the influence of the main subject teacher on students' practice behavior and learning is crucial, according to interviewed specialists, the bachelor curricula[29], and scientific literature[30]. The goal of independent practice, that is described in every instrumental bachelor curriculum[31], is mainly dependent of two specifically formulated goals of main subject lessons in the bachelor: *"At the end of this course, the student: (…) can act as his own teacher, by analyzing what determines the quality of his playing and how to maintain it; has developed effective practice and rehearsal techniques; (…)."* [30] The influence of the teacher on practice behavior has also been addressed more extensively in earlier publications from within the conservatoire, for example the combined studies by Deneer and van Zelm (2014), and the study by Koopman, Smit, de Vugt, Deneer, and den Ouden (2007), so it is interesting to revisit some of their topics.

Another important social aspect is conversation. How much do students talk with their teacher and peers about effective practicing? Discussing practice methods and interpretations may make students more conscious in their practice behavior[32]. Also, most advanced students have already acquired fruitful ideas about practicing, so sharing their knowledge would be beneficial for the performance of a whole class[33]. Lastly, the role of learning through observation (modeling) is often mentioned: seeing others play is good for learning, for several reasons. This could be a YouTube-movie, the teacher, or even a lower-level student[34].

[28] Early music scored lower than the other departments (Mean Early Music = 2,6; Mean Jazz = 3,4; Mean Classical = 3,6), but because of a small sample of Early music students (n = 13), we should be cautious with firm interpretations.
[29] Classical (p. 17), Jazz (p. 37) and Early Music (p. 18) bachelor curricula (2016-2017).
[30] Küpers et al., (2014); Varela, Abrami, & Upitis (2016); Wulf & Mornell (2008)
[31] This goal on independence was quoted in the introduction: "*At the completion of their studies, students should have acquired effective practice and rehearsal techniques for improvement through self-study.*" (p. 5, Bachelor Curricula)
[32] Zhukov (2009)
[33] Nielsen (2004)
[34] Wulf & Mornell (2008): in case of a lower-level student, one must be able to identify possible mistakes.

Table 7. Mean answers and relative distribution of answers concerning teachers and peers

	Mean	Never	Rarely	Sometimes	Often	Very often
I talk about practicing with other students.	*3,3*	3%	10%	43%	37%	6%
I practice together with other students.	*2,3*	19%	42%	27%	10%	2%
My teacher doesn't only tell what I should improve, he/she also tells me how I could practice it.	*3,7*	3%	17%	21%	32%	28%
After a lesson from my teacher, I clearly know what I should practice, and how I should do that.	*3,9*	3%	4%	22%	44%	27%
During the week, I practice the things that my teacher told me.	*3,9*	3%	6%	20%	45%	27%
My teacher tells me to practice in a way that doesn't work for me.	*2,0*	35%	38%	22%	4%	1%
My teacher gives me a lot of room for own suggestions and choices (for example in repertoire, interpretation).	*3,9*	2%	7%	21%	36%	34%

Note. Questions are framed on a 5 point scale: Ranging from Never (1), to Very Often (5). The mean answers on these questions lay between 1 and 5: closer to 1 would be more affirmative, closer to 5 would be more rejecting the statement. Percentages may not add to 100, due to rounded numbers. Smallest N= 116.

Peers

The first two questions in table 7 regard the role of peers in students' practice. Most students (80%) report to discuss practice with other students either sometimes or often. Practicing with other students however does not happen that much: 61 percent of the students never or rarely do this. A difference was found between Jazz and Classical students: Classical students practiced less together than Jazz students.[35]

Teachers

As can be seen in the last five questions in table 7, the evaluations of the teachers are considerably high. In consistency, the only negatively framed question ("*My teacher tells me to practice in a way that doesn't work for me.")* receives a low average response (*Mean* = 2,0). In conclusion of their research, Koopman and his colleagues (2007) suggested a relation between the clarity of practice instructions during the lesson and amount of structure in individual practice. Relations between the self- reports in this survey support this hypothesis: 'goal-directed practice[36]' during practice correlated with both the questions "*My teacher doesn't only tell what I should improve, he/she also tells me how I could practice it"* and *" After a lesson from my teacher, I clearly know what I should practice, and how I should do that".*[37]

[35] Mean Jazz = 2,9; Mean Classical = 2,1. Mann-Whitney test: U = 625,0; Z = -3,60; p < 0,001 (two-tailed); N = 105.
[36] The measure 'Goal-directed practice' is explained in the section on Goals, Focus, and Strategies.
[37] 'Goal-directed practice' was again measured as the computed mean of six questions, as discussed in the section on Goals, Focus, and Strategies. Spearman correlations between 'goal-directed practice and the mentioned items were respectively: N = 117; ρ = 0,189; p < 0,05 (two-tailed), and N = 118; ρ = 0,345; p < 0,001 (two-tailed).

- ***Autonomy in the lesson***

The benefit of intrinsic motivation (when an activity is rewarding in itself) over extrinsic motivation (when a consequence of an activity is the reason to perform the activity) is increasingly well known. However, according to different scientific theories[38] an even more important aspect of motivation is autonomy. In other words: more than the question whether a task or activity may be fun or not, a vital difference is whether people chose to do it. Introducing choice is shown to be beneficial for learning many different motor skills[39]. Deneer and van Zelm (2014), as well as Koopman and colleagues (2007), already emphasized the role of autonomy in the student-teacher relationship[40], so it is interesting to touch this topic again. The responses on the question *"My teacher gives me a lot of room for own suggestions and choices"* are majorly positive, with 70 percent to experience autonomy often or very often. Especially vocal and brass students responded positively: 91 percent of the vocal students experienced this autonomy often (36%) or very often (55%), and even 100 (!) percent of the brass students experienced room for own suggestions and choices, often (55%) or very often (45%). Interestingly, this autonomy item also correlated significantly with motivation[41]: autonomy and motivation seem to go hand in hand. Contrary to what teachers expected in the study by Koopman and colleagues (2007) this perceived autonomy during the lesson does not differ between different study years[42]. This could be because autonomy is relatively high in general.

- ***Modelling***

A last topic that is worth to consider is modelling: seeing and hearing someone else perform the skill or piece enables the student to develop a better mental model of the skill[43]. Students reported that their teacher plays his/ her instrument during a lesson either: Never (1%); Rarely (6%); When necessary (52%); Much (36%); or Too much (4%). We cannot say if students are really able to judge if their teachers' playing is 'Necessary' in any learning situation. But, at least we can conclude that about half of the students (52%) are content with their teachers amount of modelling, as they chose for 'When Necessary', and that a large majority of the teachers (92%) plays more than rarely. (One woodwind student even took the effort to change the statement as follows: *" my teacher plays ~~his/her~~ MY! instrument much."*)

Additional: Modelling difference jazz - classical

Specifically, 69 percent of the jazz students reported that their teacher played "much", considerably more than "when necessary"(21%). In reverse, in the classical department 66 percent of the students reported to have a teacher that played "when necessary", while 25 percent reported "Much". As to say, jazz students seem more often convinced that their teacher played more than necessary, whereas classical students were more often convinced that when the teacher played, it was necessary.

Of course, the teacher is by far not the only model available. Students reported to watch video's or live performances on their instrument either daily (32 %); more than once a week (45%); about once a week (14%); or less than once a week (8,5%). None of the students reported 'Never'.

[38] Küpers, van Dijk, McPherson, & van Geert (2014); Wulf & Lewthwaite (2016)
[39] Evans & Bonneville-Rousy (2015); Küpers et al. (2014); Wulf & Lewthwaite (2016)
[40] In the study of Van Zelm (Deneer and Van Zelm, 2014) 29 percent of the students reported that it was not the teacher who decides the topics during the lesson, and 70 percent experienced the teacher to give room for own choices in repertoire. Also, 18 percent of the students reported that making musical choices was not an important aspect of the lesson.
[41] Motivation was measured as the computed motivation variable, as described in the motivation section. Spearman correlation: N = 117; $\rho = 0{,}205$; $p < 0{,}05$ (two-tailed)
[42] Spearman correlation: N = 114; $\rho = -0{,}04$; $p = 0{,}67$
[43] Wulf & Mornell (2008)

Conclusions

This report serves to provide an overview of individual practice behavior of students at the Royal Conservatoire. The major goal of this report is to support and initiate further consideration, discussion, and research in the Royal Conservatoire. Some noteworthy findings are listed in this concluding section.

Time, breaks, pain

- 25 percent of the students reported to practice for one to two hours without taking a break in between. These were mainly students on keyboard instruments, woodwinds and plucked string instruments.
- Despite shorter practice sessions, students in the classical department reported more physical fatigue after a practice session than jazz and early music students.
- 39 percent of the students reported to have pain after practicing, either sometimes, often, or very often. Especially, a relatively large number of the woodwind students reported to have pain often.

Some students could benefit from more deliberate instruction on aspects like taking breaks, stretching, posture, building strength, and avoiding overuse and tension[44].

Goals, focus, and strategies

- Use of goals and focus are important aspects of practice[45]. Students' reports on their goal-directed practice and focus are reasonable, but these aspects can be improved. There was no difference between students in different years, suggesting an absence of improvement throughout the course.
- The same holds for the use of practice strategies: 49 percent of students frequently use at least seven different strategies to practice material. However, especially the other half of the students could benefit from increasing their number of strategies. Several strategies that are proven to be useful in certain circumstances are by far not used as much as more obvious behaviors. Students could be encouraged to use and explore, and share more different strategies, because having more different strategies is argued to be beneficial[46]. An important aspect in this is that students should especially be made aware of the specific use of any strategies, to apply them usefully. This is described further in the introduction of the academic thesis.

Goal-directed practice, the importance of focus during practice, and the deliberate use of different practice strategies could be addressed more explicitly, for example during main subject lessons[47], during group lessons in the first year, with a manual, or during introductions in the first-year-festival.

Beliefs

- Scientists and specialists already concluded that skipping a day of practice is not harmful, and is actually beneficial. The majority of students were indeed convinced that skipping practice for a day is not harmful.
- Those who say that their practice could be more effective are mainly not the same as those who report to know how to improve their practice.

[44] Interested musicians could also read the book by Janet Horvath (2010): *Playing (less) hurt. An injury prevention guide for musicians.*

[45] For more information, please read Bonneville-Roussy & Bouffard (2016), or the theoretical introduction of the academic thesis report.

[46] Jørgensen (2002); Nielsen (2004)

[47] Koopman and colleagues (2007) already observed that more structured practice instructions by the main subject teacher resulted in more structured individual practice behavior of students. This was confirmed in the current results.

Students who want to improve their practice effectiveness, but don't know how, could for example be encouraged to follow the existing elective subjects in practicing, and/or be provided an easy-to-use manual.

Motivation

- Results on motivation were mainly positive. Also, motivation was significantly linked with students' goal-directed practice and focus during practice.
- 53 percent of the students reported to be able to put themselves to practice something they don't like ('often' or 'very often'). This is difficult to interpret. Of course, not everything may be directly fun in effective practicing, and being able to regulate oneself is positive for this 53 percent of students. However, some of the other students may just like more aspects of their practice and need less stamina to start or stick to certain practice activities. Anyway, some difficulties that may actually be better for real learning of a skill feel less comfortable [48], so the conclusion remains that students may benefit from developing more self-regulation strategies.

Social: teachers and peers

- Teachers received surprisingly high ratings in students' reports on questions about the lesson in relation to individual practice. This could well be an (indirect) effect of the multitude of initiatives in the conservatoire during the last years, including examples like the research group *Teacher of the 21st Century*, the *From Potential to Performance* symposium, and a new staff development program.
- Concerning autonomy in the lesson, 70 percent of the students perceived room for own choices and suggestions ('often' or 'very often'). For brass and vocal students, this was even a remarkable 100 and 91 percent. There was no increase in this autonomy between students in different study years, contrary to expectations based on teachers' reports in the study by Koopman and colleagues (2007). This could however be because autonomy during the lesson now seems relatively high in general.
- Although most students (87%) talk about practice at least sometimes, they could be encouraged to do this more structurally and deeply. Especially, they should be encouraged to practice together, as this doesn't happen much, while it is proven to be a beneficial supplement to individual practice[49].

One final note

This report serves as an overview, not all topics have been discussed as extensively as any specific study could do. The major goal of this report on practice behavior is to inspire further consideration, discussion, and research. Students, teachers and artistic researchers could be supported to address individual practice more in conversations, lessons and research, as they can now find much useful information by themselves: there is much to read and watch after 25 years of growing research in the cognitive psychological discipline. Musicians and (artistic) researchers who are interested in developing a view on recent developments in musical practice research could start with Bonneville-Roussy and Bouffard (2015), Wulf and Lewthwaite (2016), Wulf and Mornel (2008), and Zhukov (2009), or read the academic thesis to which this report is an appendix. Any comments or questions evoked by this report can be sent to jvanketel@hotmail.com.

[48] Kornell & Bjork (2008); Kornell, Castel, Eich, & Bjork (2010); Schmidt & Bjork (1992)
[49] Nielsen (2004) ;Wulf & Mornell (2008); Zhukov (2009)

References

Bachelor Curriculum Classical (2016-2017). Royal Conservatoire, The Hague. Retrieved from: http://www.koncon.nl/files/Curriculum%20Handbooks/Curriculum%20Handbook%20Classical%20Music%2016-17%20DEF%20vs%201.1.pdf

Bachelor Curriculum Early Music (2016-2017). Royal Conservatoire, The Hague. Retrieved from: http://www.koncon.nl/files/Curriculum%20Handbooks/Curriculum%20Handbook%20Early%20Music%2016-17%20DEF%20vs.%201.0.pdf

Bachelor Curriculum Jazz (2016-2017). Royal Conservatoire, The Hague. Retrieved from: http://www.koncon.nl/files/Curriculum%20Handbooks/Curriculum%20Handbook%20Jazz%2016-17%20DEF%20vs%201.0.pdf

Bonneville-Roussy, A., & Bouffard, T. (2015). When quantity is not enough: Disentangling the roles of practice time, self-regulation and deliberate practice in musical achievement. Psychology of Music, 43(5), 686-704.

Deneer, P., van Zelm, G. (2014). Help! A talent! The student teacher relationship in Higher Music Education. The Hague: Royal Conservatoire Publications.

Evans, P., & Bonneville-Roussy, A. (2015). Self-determined motivation for practice in university music students. *Psychology of Music*, 0305735615610926.

Horvath, J. (2010). *Playing (less) hurt. An injury prevention guide for musicians.* Milwaukee, WI: Hal Leonard Books.

Jørgensen, H. (2002). Instrumental performance expertise and amount of practice among instrumental students in a conservatoire. *Music Education Research, 4*(1), 105-119.

Koopman, C., Smit, N., de Vugt, A., Deneer, P., & den Ouden, J. (2007). Focus on practice-relationships between lessons on the primary instrument and individual practice in conservatoire education. *Music Education Research, 9*(3), 373-397.

Kornell, N., & Bjork, R. A. (2008). Learning concepts and categories is spacing the "enemy of induction"?. *Psychological science, 19*(6), 585-592.

Kornell, N., Castel, A. D., Eich, T. S., & Bjork, R. A. (2010). Spacing as the friend of both memory and induction in young and older adults. Psychology and Aging, 25, 498-503.

Küpers, E., van Dijk, M., McPherson, G., & van Geert, P. (2014). A dynamic model that links skill acquisition with self-determination in instrumental music lessons. *Musicae Scientiae, 18*(1), 17-34.

Nielsen, S. G. (2004). Strategies and self-efficacy beliefs in instrumental and vocal individual practice: A study of students in higher music education. *Psychology of Music, 32*(4), 418-431.

Schmidt, R.A., & Bjork, R.A. (1992). New conceptualizations of practice: Common principles in three paradigms suggest new concepts for training. *Psychological Science, 3*(4), 201-217.

Schunk, D. H., & Zimmerman, B. J. (Eds.). (1998). *Self-regulated learning: From teaching to self-reflective practice*. NY: Guilford Press.

Varela, W., Abrami, P. C., & Upitis, R. (2016). Self-regulation and music learning: A systematic review. *Psychology of Music, 44*(1), 55-74 .

Williamon, A., & Valentine, E. (2000). Quantity and quality of music practice as predictors of performance quality. *British Journal of Psychology, 91*, 353–376.

Williams, S.G. (2014). Guidelines for performers and teachers. In Van Den Bergen, M., Borgdorff, H., Karsten, W., Prchal, M., & Williams, S.G. (Ed.). *From potential to performance* (p. 8 - 20). The Hague: Royal Conservatoire. Retrieved from: http://issuu.com/koninklijkconservatorium/docs/from_potential_to_performance_web/1?e=5813435/8128498

Wulf, G., & Lewthwaite, R. (2016). Optimizing performance through intrinsic motivation and attention for learning: The OPTIMAL theory of motor learning. *Psychonomic Bulletin & Review*, 1-33.

Wulf, G., & Mornell, A. (2008). Insights about practice from the perspective of motor learning: a review. *Music Performance Research, 2*, 1-25.

Zhukov, K. (2009). Effective practising: a research perspective. *Australian Journal of Music Education,* (1), 3.