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Key characteristics of movement in an instrumentalist's motor skills – the example of playing the violin

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Abstract:

Background and Study Aim: The foundation of effective musical instrument playing lies not only in a keen ear but also in high-quality motor skills. This seemingly obvious fact is not reflected in the core criteria for the training of instrumental music teachers. Meanwhile, the paradigm of human motor skills research is dominated by movement patterns from the world of sport. Therefore, the implementation of this knowledge into the field of music education requires an innovative approach from both music educators and experts in human motor skills. The scientific expertise of the collaborating experts is a key factor in resolving this multifaceted problem, which is intriguing both cognitively and in terms of its practical application. The aim of the empirical research undertaken was to adapt to the field of music education those 'movement characteristics)' which are primarily used to assess the motor skills of athletes or the motor skills of children and adults for the purposes of physical education, health promotion, physiotherapy and rehabilitation.

Material and Methods: The Delphi method was employed. In the first stage, five experienced string instrument teachers were asked to identify which of the 9 'movement characteristics (features)' defined by Günter Schnabel could be applied to the assessment of the motor components of musical tasks performed during standard sessions (lessons). The reference framework for the assessment of 'movement characteristics' is the artistic effect, traditionally evaluated on a 25-point scale. Three people participated in the second and third stages of the Delphi method: an expert in violin teaching with over thirty years' experience who is also a certified fitness instructor, and two experts in human motor skills (kinesiology) with academic qualifications in medical and health sciences, specialising in sport science (professor and PhD), who are also amateur musicians.

Results: Music teachers described their own interpretations of Schnabel's definition using metaphorical language that bore no relation to kinesiological terminology and was, moreover, internally inconsistent. Nevertheless, these teachers unanimously identified 'rhythm', 'tempo' and 'force' as elements of a musician's motor skills that could be assessed by an expert, but their descriptions of these phenomena were completely inconsistent (more intuitive and emotional). When a violin teaching expert with basic motor fitness competencies posed the same question to researchers specialising in various aspects of human motor skills (drawing on their own instrumental experience), they jointly identified 5 'movement characteristics': accuracy, rhythm, range, force, tempo.

Conclusions: The most challenging stage in adapting the methodological principles of kinesiology to instrumental music teaching will be the development of criteria for identifying

Glossary:

The Delphi method (Delphi technique) – a method of group decision-making and forecasting that involves successively collating the judgments of experts [97].

Experimentum crucis – (English: crucial experiment or critical experiment) is an experiment capable of decisively determining whether or not a particular hypothesis or theory is superior to all others whose acceptance is currently widespread in the scientific community.

Observational learning – the process by which learners acquire the capability for action by observing the performance of others [40, p. 231].

Motor skill – a skill for which the primary determinant of success is the quality of the movement that the performer produces [40]

Simple reaction – a response to a single unanticipated stimulus [73].

specific 'movement characteristics/movement features' that are accepted and understood by teachers of a particular instrument. The difficulty is all the greater because the basis for such identification is the artistic effect (the arrangement of notes, and often a very short phrase, or even a single sound). This concerns the competence to professionally apply mixed assessments: motor-artistic. This entails drawing on praxeological knowledge, and the problem as a whole points to the necessity of using complementary research methodologies. From two perspectives – methodological and pragmatic – there is an interesting issue that we omitted in this work: 'situational actionability' (the situational possibility of action).

Keywords: complementary research methodology, dispositional feasibility, motivation, praxeology, situational actionability

Choice reaction – a response to stimuli using acquired movement patters [73].

Movement time – the interval of time that elapses from the beginning to the end of a movement [40, p. 85].

Latency – from the occurrence of the stimulus to the commencement of a movement [73].

1. Introduction

Even the rather sweeping simplification that an instrumentalist's achievement of artistic goals is linked to the need to reproduce the sounds of a piece's musical notation as perfectly as possible highlights a key component of motor function. In other words, it seems self-evident that the foundation of effective musical instrument playing lies not only in aural ability but also in the quality of motor skills. This apparent self-evidence is not reflected in the fundamental criteria for the training of instrumental music teachers. The paradox lies in the fact that music teachers (including vocal teachers) do in fact use mixed assessment criteria (motor and artistic), but it is not certain whether everyone possesses the competences optimal for this profession, encompassing scientific knowledge of the fundamentals of human motor skills (kinesiology) and of praxeology. At least the Polish system of institutional training for music teachers at higher education level does not include such subjects. It is precisely praxeology that identifies mixed judgements as a methodological category with universal applications. This phenomenon is illustrated by efficiency-ethical judgements in the foundational treatise on praxeology [1, 2] and in the encyclopaedic entries on this discipline [3]. However, agonology (general theory of struggle [4]) was published by T. Kotarbiński 17 years earlier (1938) before the first edition of *A Treatise on Good Work* [1] and included as chapter 13 of *A Treatise…* and titled *Technique of struggle* [2]. Therefore, publications devoted to the subject of mixed assessment in agonology [5-7] are, in fact, merely a more detailed aspect of praxeology.

Formally, as is the case throughout the Polish education system, first- and second-level music schools and other arts schools use a six-point grading scale: 6 – excellent; 5 – very good; 4 – good; 3 – satisfactory; 2 – pass; 1 – fail [8, 9]. However, internal systems for assessing pupils' progress (as part of compulsory 'technical auditions') traditionally employ a 25-point scale (details in the 'Material and Methods' section). Furthermore, the guidelines for classifying pupils also include the undefined term 'technical-performance tasks' [10-12]. These terms are distinctly part of music teachers' jargon, and the circumstances in which they are used exemplify the deepening of methodological barriers as well as those in communication between music experts and specialists in scientific disciplines and/or practices based primarily on motor activities. After all, the knowledge and experience of, for example, sports educators or physiotherapists can be of fundamental importance in consultations with music educators – to the benefit of each of these professional groups. However, given that most of the terms used in these contexts ('technics', agonology, performance', 'task'), are key concepts in praxeology [3], this all the more highlights the need to

explore the issue from a complementary perspective, whilst maintaining precise language.

However, the situation is complicated by the fact that, due to historical and political complexities, praxeology [13], together with remains an esoteric discipline today [14, 15]. This is particularly true for those who do not speak Polish, but also because, for generations, praxeology has been overlooked in Polish education – and not just in the training of music teachers. Apart from a few independent initiatives (e.g. a research methodology dedicated to the practice of physical education, sport and physiotherapy based on the criteria of praxeology [16], or the academic programme in Wrocław, where the tradition of sports praxeology stretches from the 1970s right up to the present day [17-26]), this discipline is beginning to be rediscovered. This last statement does not contradict the fact that the praxeology developed by Tadeusz Kotarbiński [1, 2] has for quite some time been recognised explicitly as a general methodology. This is the view taken by T. Pszczołowski, who concludes: 'Praxeology is followed by a general methodology of the sciences, because scientific activity is merely a certain kind of purposeful activity' [13, p. 268]. Other researchers, however, have expressed a similar view in a more measured, and even somewhat indirect, manner [27-31]. Nowadays, praxeology, together with agonology, is recommended as the fundamental frame of reference for the methodology of complementary research currently being developed [32, 33; 7, 34].

Furthermore, given that the terms 'technical audition' and 'technical-performance tasks' are not defined, there is no methodological basis for classifying them as part of the technical vocabulary of music teachers, even in the broadest sense (taking into account all specialisms: instrumental studies, rhythmic and vocal studies). Meanwhile, most of the words used in these terms ('task', 'technics', performance'), are key concepts in praxeology [3]. However, the issue is most complicated by the ambiguity and spelling of the term 'technics'. In Polish, it is always 'technika'; thus, it is no different in the encyclopaedia of praxeology [3]. Firstly, under the entry '**Technika** (a. technics, engineering …)' [3, p. 244], and subsequently amongst the indexes of English terms: 'engineering' [3, p. 308] and 'technics' [3, p. 314]. Thus, a discerning critic would rightly point out that, since Janusz Groszkowski [35], in a Polish-language publication explaining the three meanings of this word, draws attention to the subtleties of spelling in English depending on the context, failure to respect this fact causes significant information noise. The effects are particularly evident in references to the field of music education; since the central aspect of this education is sound quality, an outside observer is justified in associating, particularly the term 'technical audition', with the use of some kind of technical equipment to verify that quality.

Groszkowski [35, p. 58] explains precisely (in my own free translation for the purposes of this work) that 'in the first sense, the word "technology" refers to a broad field of knowledge and science that has developed within certain disciplines, primarily physics and chemistry, with the contribution of mathematics. It is therefore more correct to use the term 'technical sciences' here (…) In the second sense, the word 'technique' denotes the totality of means and skills that enable the performance of a particular activity within the scope of human endeavour. We speak, for example, of the technique of calculation, the technique of pole vaulting, the technique of piano playing, the technique of painting, and so on.' With this explanation, Groszkowski alludes – albeit not directly – to the praxeological meaning of the term in question, which is, unfortunately, largely misindexed in the encyclopaedia of praxeology under the terms 'technics' and 'engineering' [3, p. 244, 308, 314].

In this encyclopaedia, the entry is discussed over several paragraphs. In its basic sense, it refers to 'a class of activities involving the design, manufacture or operation of equipment'. Immediately following this definition (but without the alternative term 'engineering') a narrower meaning of the term 'technics' is given, as understood by Wojciech Gasparski [36, p. 119]: 'activities whose internal aim is the production and operation of technical objects, whilst their external aim is to fulfil the necessary condition for the instrumentalisations of activities constituting the universal set D, where D is the set of all human activities'. Given these terminological complexities, it is important to ask whether a musical instrument is a 'technical object', especially since the encyclopaedia of praxeology contains no such explanation under either the entry 'object' or 'instrument' [3].

Groszkowski's further explanations [35] clarify, as it were, the use of the term 'technics' (Polish: 'technika') in a linguistic sense and from the perspective of a universal set of all human activities, which also includes playing musical instruments. Groszkowski continues: 'In English, these two meanings are perfectly understood; they are expressed by two terms that are spelled differently and sound slightly different. The first meaning – technical sciences – is technics, with the stress on the first syllable and the letter 'c' in the second syllable. The second meaning, however – method of execution, skill, art – is – *techniques* with the stress on the second syllable and the letter '*q*'. The third meaning of the word 'technika' (according to Polish spelling) is illustrated by the phrase 'a technologically advanced country'.

Furthermore, the issue of human motor skills in relation to instrumental music is further complicated by several significant factors. Perhaps one of the most fundamental is the predominance, within the field of human motor skills (particularly in its early stages of development, as well as in the new specialism of *Adapted Physical Activity*), of methods tailored to movement patterns for the purposes of sport and, to some extent, physical education. Consequently, the application of these methods and knowledge to the field of music education requires an innovative approach not only from music teachers, but also from experts in human motor skills and research methodologists involved in research projects. In our view, the factor most likely to lead to a solution to this multifaceted problem – which is intriguing from both a cognitive and an applied perspective – is, above all, adherence to standards of methodological soundness in a complementary framework.

In the case of this project, an external factor which, in a sense, accelerated the validation process for the method presented in this paper was the need for remote teaching of pupils at first- and second-level music schools in Poland during the COVID-19 pandemic (as decided by the country's education authorities). Consequently, in accordance with the general principle of independence in educational decision-making – including the use of innovative teaching methods and the evaluation of learning outcomes – the final choice rests with the teacher. Similarly, the teacher's academic interests and any other factors that may inspire a creative approach to the educational process play a role. A factor providing a degree of comfort in undertaking such initiatives is the principle of teaching each pupil to play a specific musical instrument during individual sessions (lessons).

The aim of the empirical research undertaken was to adapt, for the purposes of music education, those 'movement characteristics' which are primarily used to assess the motor skills of athletes or the motor skills of children and adults in the fields of physical education, health promotion, physiotherapy and rehabilitation.

2. Materials and Methods

The Delphi method in adapting the 'movement characteristics' classification for use in the education of instrumental musicians

Stage 1

In the first stage, five experienced teachers of string instruments (and therefore also proficient in using the 25-point assessment scale as part of the compulsory 'technical auditions') expressed an interest in the concept of 'movement characteristics (features)' from the perspective of the specific nature of playing the violin or the guitar. They were asked to indicate which of the 9 'movement characteristics' defined by Günter Schnabel [37] and by Joachim Raczek et al. [38] – reduced to concise descriptions – could be applied to assess the motor components of a musician whilst performing musical tasks (both during standard lessons and within other forms of music education and concerts). Each participant was informed that they could be provided with what was then the most recent Polish-language textbook on human motor skills [39], as well as the Polish-language version of the well-known monograph by Schmidt RA & Wrisberg CA. Motor Learning and Performance [40]. They were asked to express their opinion on the 'Expert Interpretation Card for Movement Characteristics' they received, in relation to playing a musical instrument in accordance with their specialism (Table 1).

Table 1. The content of the 'Expert Interpretation Sheet on Movement Characteristics', presented in an editorial format accessible to the reader of this paper (the order of characteristics is in accordance with Polish-language publications [41, 39])..

I would respectfully ask you, as a competent judge, to give your opinion on the possibility of assessing a musician's movement characteristics using the approach adopted in the field of human motor skills. Participation is voluntary and anonymous.

A. In your opinion, are any of the characteristics unclear (please specify the code/codes) ……..……..…

B. In your opinion, are there any characteristics that can be said to be shared by synonyms? (Please indicate such pairs of codes – or even more codes – if, in your view, they are synonyms for the same phenomenon) ……..……..…

C. Did any observations occur to you whilst you were making your assessments? If so, please do share them. ……..….....…….……...

Movement characteristics (movement feature)			**Four columns of answers**
code	**feature name**	**characteristics**	
1	**structure**	spatio-temporal organisation of movement	Identify and describe (as briefly as possible) which characteristics are appropriate indicators of the movement of the body parts specific to your musical specialism: - right hand; - left hand; - legs; - other comments
2	**rhythm**	dynamic-temporal organisation of movement	
3	**fluency**	continuity of the movement's flow	
4	**accuracy**	the degree of alignment between the result and the objective	
5	**coupling**	their relationship to one another, their combination or transfer	
6	**stability**	degree of consistency in repeated movements	
7	**range**	the spatial extent of the movement's path	
8	**force (power)**	the magnitude of the force affecting the movement	
9	**tempo**	frequency of movements	

Stage 2

As these instrumental music teachers did not understand the terminology used to describe the elements of human motor skills (see 'Results' section), an interdisciplinary team of three experts undertook the next stage of adapting G. Schnabel's classification [37] for use in motor learning within the field of music.

The careful selection of the panel made it possible to combine advanced expertise in the fields of music, health science and sport science. This structure of the expert group provided a comprehensive insight into the issue under analysis, integrating knowledge of kinesiology (anthropomotorics) and motor learning with many years' experience in musical practice and teaching: Expert 1 (music education and fitness): a professional with over 30 years' experience in teaching the violin, who is also a certified fitness instructor; Experts 2 and 3 (kinesiology, motor learning and amateur music): two academic staff members (a professor and a PhD holder) specialising in motor learning, kinesiology, health science and sport science the professor is also a praxeologist), who are amateur guitarists in their private lives.

Furthermore, Expert 1, as the only professional music teacher (specialising in the violin) in this team, has participated since 2019 in several key methodological initiatives organised by Expert 2: seminars on praxeology and the methodology of complementary research; workshops analysing his original lectures on kinesiology and Adapted Physical Activity (APA) aimed at physiotherapy students; and regular interdisciplinary brainstorming sessions (IBS) involving other academics interested in the new scientific sub-discipline of innovative agonology (INNOAGON [41-47, 7, 45-48]).

In a sense, the event that tied these activities together – but this time in an appealingly practical way – was Expert 1's decision to take up skiing in 2019. This experience vividly demonstrated that effectively teaching a person new motor skills - seemingly far removed from instrumental performance – requires, above all, a basic understanding of the morphological and functional underpinnings of the human body at a specific age, as well as providing the learner with optimal motor models (observational learning [40]). Factors closely linked to these principles include knowledge of human psychological potential (more broadly: the mental realm) and the ability to apply this knowledge in the process of motor learning, whatever that may entail.

Since 2019, Expert 1 has published, either individually or in collaboration with members of these IBS, works that demonstrate interdisciplinary expertise in a complementary manner; and, from the AHFE2024 edition onwards, as part of the new Preventive Medicine and Innovative Agonology [49].

Stage 3

Further methodological criteria for the evaluation of rhythmic characteristics in instrumental music

Elementary assumptions – first collection

1. The team of experts arbitrarily based their exploration of the phenomenon on praxeological criteria, equating the 'possibility of action' with 'dispositional feasibility': strength, intellectual or manipulative prowess, knowledge (skill) and willingness sufficient to perform a given action [3, p. 124]. Pointing to this specific understanding of the term 'dispositional feasibility' (after all, the Encyclopaedia of Praxeology

explains two further meanings, alongside the threefold understanding of the 'possibility of action' of a given agent at a specific time) also indirectly highlights two issues. Firstly, that playing any musical instrument is merely one specific instance of the necessity to coherently combine motor and intellectual potential with free will, when achieving a goal requires the use of a tool. Secondly, that praxeology formulates the most general methodological criteria within the realm of phenomena, without which no action requiring the conscious use of mind and body would be possible, let alone when instrumentalisations is necessary in given circumstances.

2. By definition of 'dispositional feasibility', it becomes clear that 'force' (in place of the variable 'strength') is distinct from the other recommended movement characteristics. However, since 'tempo' in written music notation is a rule placed above the stave next to the treble clef, experts have included this movement characteristics amongst the variables contained in the sequence of definitions for 'intellectual or manipulative prowess, knowledge (skill)'.

3. Guided by suggestions from Stage 1 music teachers, as well as their own experience, the expert panel supplemented this framework with three variables: accuracy, range and rhythm. Furthermore, they highlighted two limitations in the assessment of instrumental music. Firstly, only under certain circumstances are 'force' and 'range' characteristics of a musician's movement that can be assessed analytically, that is, by precisely identifying a single note or chord in relation to any given section of a piece. Secondly, the assessment of any of the three remaining characteristics of an instrumentalist's movement ('tempo', 'rhythm' and 'accuracy') is based on synthetic evaluations relating either to the piece as a whole or to its significant sections (musical phrasing, sentence music, period). It is therefore clear that 'force' and 'range' are components of the evaluation of the three separately listed categories of movement characteristics (movement features) in an instrumentalist's playing, but not the other way round.

Elementary assumptions – second collection

A teacher (expert) in instrumental music who is proficient in the 25-step 'technical audition' scale and who meets the three criteria set out below may proceed to a collective assessment of the movement characteristics of an instrumentalist specialising in a given field, that is, in collaboration with experts representing a level equivalent to these standards: 1) understands the significance of this phenomenon; 2) understands and accepts the conceptualisation of movement characteristics in instrumental music for the purposes of further theoretical and empirical research, as well as the necessity of employing the languages of academic disciplines capable of complementarily addressing practical problems in instrumental music teaching in a general sense and across a variety of instruments; 3) formulates their own assessments on an ongoing basis in a manner very similar to the equally subjective assessments of experts with very similar qualifications.

Main implications

1. The third criterion can be met with a tolerance of 1 point, as either the current ratings for a given feature will be consistent, or the differing expert results will fall on the borderline between neighbouring criteria in the 'technical auditions'. An example illustrating the validity of this assumption is the 1-point range of the evaluation criteria for the 'pass' grade (11 or 12 points) [10-12].

2. Even with such rigorous guidelines, it is impossible to overlook the fact that the likelihood of these assessments being objectified can be increased by utilising modern technology during the process of verifying the relative consistency of expert assessments (in the absence of such technology, the empirical data will remain useful in addressing this particular issue).

3. The ability to play back a recorded audio track repeatedly whilst observing the instrumentalist's motor skills - whether in relation to the whole of an educational session (lesson) or any part of it, or indeed a master's concert, etc. – is the most reliable way of objectifying final assessments.

4. Leaving aside the technological possibilities for modulating sound, the instrumentalist's motor interventions, inspired by such extensive knowledge, are directly linked to modifications in the movement of those parts of the body that will produce the desired effect. This is a key prerequisite for formulating clear instructions (motor commands) that can be understood by the pupil and others involved in music education.

5. Expert 1's experience was decisive in formulating a rigorous principle for categorising the results of the 'dispositional feasibility' assessment into two categories, referred to in technical terms as: 'music reading' and 'playing (or singing) from memory'. This principle therefore applies to both instrumental and vocal music. The smaller the discrepancy between the assessments, the greater the likelihood that the result is determined by talent rather than by the methods used or the pupil's diligence.

Case study

Specific circumstances of empirical research

Two pupils of the same teacher, from the same music school, were observed whilst attending remote lessons during the COVID-19 pandemic. The observations took place from 1 April to 29 May 2020. Apart from the common factors mentioned above, there was one further similarity: the remote observation of the pupils during 16 lessons took place on the same days but at different times, which is the essence of education based on individual teacher-pupil sessions. The specific methods used are a consequence of the results of stages 2 and 3.

The main reason for presenting the results of these observations five years after the end of the COVID-19 pandemic is the continuing inability to assemble a team of at least three music teachers who specialise in playing the same instrument, whilst also possessing methodological expertise similar to that of Expert 1. In this situation, it is not feasible to carry out the further validation procedure for the method presented, which is based on comparing independent assessments by this group of experts (without going into further details at this stage).

However, it was possible to obtain empirical data from the field of practice because one violin teacher made use of the right enjoyed by every teacher in Poland not only to freely choose the methods they consider best for achieving educational objectives, but also to apply his own criteria for assessing interim outcomes during the course of the programme (provided that these methods and any innovations do not pose a threat to the pupil's health or life and are permissible under the law in the broadest sense). He also made use of the freedom to choose his own academic interests and the opportunity to collaborate with scholars and anyone who could contribute to his development -

particularly his professional competence. He also made use of the privilege of sharing his knowledge and experience in the most effective way, namely through publications.

Participant

At the time, Camilla, aged 14, was a pupil in the fifth year of the first-level course, having played the violin for 60 months. Alex, aged 8, was a pupil in the first year of the first-level course, having played for 10 months (including a previous period of private tuition). The pupils' names have been changed to comply with the GDPR.

Assessment of motor-artistic skills and motivation

The main rationale for basing the assessment of motor competences on five of the nine recommended movement characteristics [37-39], as well as on the pupil's motivation during sessions (lessons) of playing a given instrument, was the experts' decision to apply the praxeological criteria of 'dispositional feasibility' (stage 3). Since the quality of sound depends directly on the quality of motor actions (abstracting from the factor of musical ear), the artistic component is, as it were, the dominant criterion for formulating composite assessments of the identified characteristics: force, range, tempo, rhythm and accuracy. In line with the six-grade grading scale used in the Polish education system [8, 9], the criteria are as follows, ranging from the highest grade 6 (excellent) to the lowest grade 1 (unsatisfactory): 25 marks – excellent; 21 to 24 – very good; from 16 to 20 – good; from 13 to 15 – satisfactory; 11 or 12 – pass; from 0 to 10 – unsatisfactory [10-12].

Stability of motor-artistic skills: within the five movement features analysed, it is possible to identify three categories of stability: strict, relatively strict (where the difference between scores does not exceed 1 point), and lack of stability (where at least one score differs from the others by 2 points or more).

Measuring motivation: based on a 10-point scale. The application of this simple 10-degree scale of motivation to the physical efforts of an adolescent violinist does not mandate interpretations based on contemporary psychology's use of the Work Extrinsic And Intrinsic Motivation Scale [50, 51].

Motor-artistic skills and motivation were assessed three times during each lesson: before, during, and at the end of the session. The third assessment of motivation, carried out after the music exercises had finished, is in fact a measure of 'self-motivation' to practice at home, free from any pressure from the teacher.

Statistical analysis

The estimation of the results is based on the following indicators: frequency (n); mean (M); minimum (Min); Maximum (Max); ratio (%). The Pearson correlation coefficient between pairs of specified variables was calculated (r) and also coefficient of determination (R2); significance test: independent correlation coefficients; correlated correlation coefficients. Furthermore, we based our analysis on the chi-squared test (χ^2), test of independence for contingency tables 3 x 3 or 2 x 2; and calculated contingency coefficient (C). Other indicators: degrees of freedom (df); significance level, probability (p).).

3. Results

Stage 1

Three teachers unanimously agreed that the characteristic 'structure' was incomprehensible, and they also unanimously identified 'force (power)', 'rhythm' and 'tempo' as features of musical motor skills that could be assessed by experts. Furthermore, two of them made similar critical remarks regarding the obscure language used in the descriptions provided by G. Schnabel [37]. However, the violinists' own interpretations of the indicators for the given movement features related to 8 of them (omitting only 'structure'). Their own interpretations were inconsistent and full of metaphors, and thus deviated from scientific kinesiological terminology. The use of such language (or terminology) indicates that the individual in question does not understand the nature of the phenomena being described. After all, the aim is to link specific movements of the musician's body to the movement features defined by Schnabel [37]. These body movements should be sufficiently clear and unambiguous for different observers to be able, in agreement and independently of one another, to recognise them as relatively objective evidence (indicators) of conformity with Schnabel's classification.

For example, one of these teachers describes 'accuracy', in relation to a violinist's right hand, as 'precision of execution, rhythmic and dynamic', whilst omitting any discussion of the left hand's movement. 'Force (power)', in relation to the right hand, is interpreted as 'bow support; fast, relaxed, alternating bow strokes'. The motor skills of the left hand, on the other hand, are described as: 'resonant sound in the high positions and on the G string; varied vibrato'. 'Tempo', in relation to the right hand, is, in his view, 'the ability to play very fast and very slow alternating bow strokes', whilst for the left hand it is 'finger dexterity and independence'.

Stage 2

As a result of the second stage, the team of three experts identified five ('movement characteristics'): 'accuracy', 'force (power)', 'range', 'rhythm', 'tempo', which can be assessed through careful observation of the pupil during instrumental music lessons, provided that the teacher has acquired the relevant interdisciplinary competences.

Stage 3

Definitions of recommended movement characteristics (movement features) with commentary

Force (human force or power) of a musician refers to the pressure applied with the relevant parts of the body, either directly or indirectly via the bow, drumsticks, etc. on those parts of the musical instrument (taking into account its specific characteristics) which produce sounds or chords that are either appropriate (positive assessment) or inappropriate (negative assessment) to the musical notation of the piece.

Comments

1. For example, when playing the violin or viola, the fingers of the upper limbs and the chin play the dominant role, whilst when playing wind instruments the tongue and

exsthost movements caused by the activation of the diaphragm and others the intercostal muscles.

2. In the encyclopaedic sense of praxeology, **human force (power)** means that 'an agent possesses a certain amount of force, i.e. is capable of performing a certain amount of work in the physical sense by activating their muscles or executing a specific sequence of internal impulses. If someone is unable to lift a heavy object or is unable to lift it a certain number of times, we say that that person lacks sufficient force, which can be quantified. Failing to recognise a lack of force commensurate with the task is one of the causes of practical error [3, p. 219].

3. Since human force is the fundamental cause of sound production on an instrument, an instrumental music teacher with complementary professional competences should correctly identify the parts of the body responsible for this phenomenon, name them in accordance with human anatomical terminology, and know-how and in what order to use them (correcting any practical errors), in order to achieve a tone that conforms to the intersubjective assessment of experts, inspired by the composer's score and the evaluation standards established through practice. The sequence of internal impulses, on the other hand, refers to the musician's actions, which are indirectly verified by motor-artistic effects during the part of the session technically known as 'reading music'.

A musician's **range** refers to motor adjustments, such as the pressure applied by the bow to the string or strings of the violin during the required duration of a given note and the alternation of notes at the piece's set tempo; these elements can be estimated with relative precision using quantitative indicators (milliseconds, BPN, decibels, etc.); however, the most accessible external measure of the quality of this characteristic is visual assessment, e.g. not only of the movements of the hand manipulating the bow within its standard length and width, utilising the anatomical and functional properties of both hands, but also of the head muscles that determine the stability of the violin.

Comments

1. Experts specialising in a particular instrument may find it inspiring to study research on motor skills in individuals practising a wide range of sports and disciplines (archery, artistic gymnastics, billiard, bowling, fencing, golf, hockey, kendo, pool, rockets sports, swimming, etc.), as well as those practicing calligraphy, dance, painting, pantomime, theatrical performance, etc.). Among the key cognitive benefits,

we identify the descriptions used to explain the movements of body parts that are crucial to achieving mastery in these activities, presented without technical jargon.

Tempo is the sequence of motor actions involved in producing sounds from a musical instrument over time, in such a way that the melody corresponds to the composer's notation written above the stave, next to the treble clef.

Comments

1. According to Italian terminology, examples of tempo categories (with an approximate range of beats per minute − BPM): adagio (55 to 76); allegretto (104 to 120); allegro (120 to 160). Consequently, the varying gauge range (measured in BPM) of individual tempo categories in music is a factor that may influence the subjective differences in experts' assessments, as these are based on their own auditory impressions rather than on instrumental measurements.

2. Gauge (limit), in the praxeological sense, is 'the difference between the boundary values contained in a standard, the exceeding of which affects the assessment of the effectiveness of an action' [3, p. 253].

3. The language of praxeology distinguishes between a real pattern and an ideal pattern. 'By a real pattern we mean a perceptible thing to which the intended product is to be most similar in a given respect … On the other hand, we speak of an ideal pattern whenever the aim is determined not by pointing to a perceptible thing, but by a description answering the question of what the intended product is to be like in a given respect' [3, p. 282]. Expert evaluation in music relates to the ideal pattern.

Rhythm – the ability to manipulate parts of the body used both to produce repeated sequences of similar sounds (chords), as well as observing the necessary pauses between distinct fragments (phrases or longer segments) in the composition being performed, in such a way as to emphasise the variety of timbre within the melodic line or musical motif at the times and in the order intended by the composer, as identified by the dominance of this movement feature.

Comments

1. This definition elaborates on the praxeological understanding of rhythm: 'movement occurring in time to a beat, the even distribution over time of events that are similar to one another in some respect' [3, p. 214], whereby this 'some respect' gives rise to mixed (motor-artistic) evaluations.

2. In other words, the definition serves as a guideline for an expert specialising in playing a given instrument, enabling them to determine – in accordance with the terminology of scientific knowledge concerning human motor skills and anatomy – how to use parts of the body in a manner appropriate to the required temporal distribution

of sounds, but also to consciously refrain from producing any sounds from the instrument, in order to faithfully fulfil the composer's criteria.

For a musician, accuracy is the most general measure of the degree to which their motor actions correspond to the artistic effect achieved, and it applies both to the piece as a whole and to its individual sections.

Comments

1. In the encyclopaedia of praxeology, 'accuracy' is discussed under the entry for **'exact'** ('similar to a model in some specific respect' [3, p. 49]. Immediately following this definition, the encyclopaedia's author quotes T. Kotarbiński's interpretation from *A Treatise on Good Work*, in which the word 'accuracy' appears: 'We therefore define accuracy as follows: the more precisely a given task is performed in a given respect, the less the product differs from the standard in that respect'.

2. Further interpretations of the term 'accuracy' in the encyclopaedia of praxeology are of particular cognitive value from the perspective of its use in music education in its broadest sense: 'The various criteria on the basis of which we compare a product (thing) or an action (event) with a standard include the concepts of successful, well-turned (Correct), precision' [3, p. 49].

3. According to the encyclopaedia's author, the general meaning of 'accuracy' is based on *the Wielka Encyklopedia Powszechna PWN* (*Great Universal Encyclopaedia PWN*) of that period '– a measure of proficiency in the practical use, under specific conditions, of the precise means available; in this praxeological sense, one can therefore be, in a given situation, both "precise" (e.g. by possessing a highly sensitive measuring instrument) and, at the same time, not very accurate (e.g. by making inappropriate use of that instrument), but not the other way round'

4. In our view, distinguishing between the concepts of 'accuracy' and 'precision' is particularly useful in the field of instrumental music theory and practice. T. Pszczołowski refers to the Swiss psychologist Éduardo Claparède [52]: 'Dictionaries often define the terms "accuracy" and "precision" in such a way that accuracy is defined by precision and vice versa. To prevent the two concepts from being confused, it seems essential to distinguish them clearly and associate them with different concepts. Accuracy is an objective characteristic, in the sense that it is determined by conformity with some external phenomenon: accuracy is therefore inversely proportional to the constant error, or, in the case of a single instance, to the known error. Precision is, so to speak, a subjective characteristic, in the sense that it is determined by the consistency of the response of an instrument or an individual. If an instrument does not make systematic errors, it is said to be perfect; if, on the other hand, it does not make random errors, it is said to be precise. An instrument may possess both characteristics at the same time, or neither. Similarly, with regard to a person, the two terms denote two distinct abilities, which may not occur simultaneously' [3, pp. 49-50].

Cause study

Overall indicators of 'dispositional feasibility' in each of the three parts of the 16-session violin tuition cycle, together with a comprehensive motor and artistic assessment.

All of Camilla's motor and artistic marks are higher than Alex's. Camilla received her highest mark for part 'A', whilst Alex received his for part 'B'. his result for Alex is significant in terms of the differentiation of musical task content. During sections 1 and 11 of this part, she practised 'sight-reading', which is recognised by professionals as a highly selective element in the early stages of musical education. Both pupils performed musical exercises from memory during part 'A' of all 16 sessions, whilst Camilla also did so during part 'B'. Camilla practised 'music-reading' during five sessions of part 'C' (1, 3, 4, 6, 7), motivation (as measured by the average score) was lowest (M = 67% of the maximum) before the start of each part 'A' of the session, subsequently, her motor and artistic skills were assessed within the range of 76–100% of the adopted criteria. Meanwhile, during part 'C', the ratings for these skills were the lowest, but her motivation for independent work was the highest (91 percent) and 12 percent higher than her motivation prior to part 'B'. The greatest difference in the motivation reported by Camilla was between part 'A' and part 'C' (24%) and is statistically significant ($p<0.01$). Furthermore, the 12 percent difference in declared motivation between part 'B' and part 'C', that is, regarding independent work – is statistically significant ($p<0.05$) (Table 2).

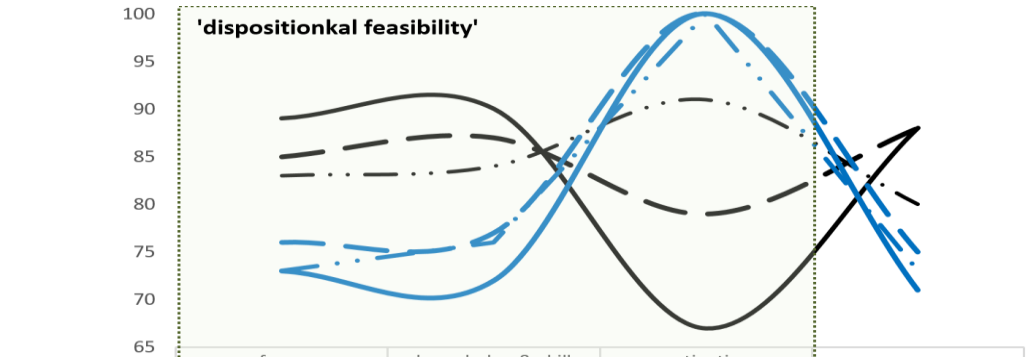
Table 2. The arithmetic means, minimum and maximum values of the 'dispositional feasibility' and 'accuracy' indices following the decomposition of the raw results into proportion indices (in %), as well as the correlations between these variables, taking into account the criterion of division into three parts of session, separately for the female pupils observed.

Camilla					**Alex**			
Part of session	**'Dispositional feasibility' indicators**			**'Accuracy'**	**'Dispositional feasibility' indicators**			**'Accuracy'**
	'force'	**'knowledge & skill'**	**'motivation'**		**'force'**	**'knowledge & skill'**	**'motivation'**	
'A'	89.2 (80-100)	89.6 (79-99)	67 (40-90)	88 (76-96)	72.5 (56-88)	71.9 (61-88)	100	70.8 (56-88)
'B'	84.8 (68-100)	86.8 (71-100)	79 (50-90)	88 (76-96)	76 (56-88)	76.8 (56-87)	100	75.2 (56-88)
'C'	82.8 (64-100)	83.6 (60-100)	91 (70-100)	80.4 (56-96)	73.2 (60-88)	76 (59-91)	100	73.2 (60-88)
differences								
'A' vs 'B'	4.4	2.8	12	0	5.3	4.9	0	4.4
'A' vs 'C'	6.4	6	**24****	7.6	0.7	4.1	0	2.4
'B' vs 'C'	2	3.2	**12***	7.6	2.8	0.8	0	2
correlations of general indicators of the phenomena studied								
part of session		**'A'**	**'B'**	*p<0.05 **p<0.01 ***p<0.001		**'A'**	**'B'**	
'B'		0.929	**x**			**0.999*****	**x**	
'C'		−0.935	**−0.961***			**0.994*****	**0.998*****	

Eight-year-old Alex's consistently high level of motivation for every part of every violin lesson, as one of the four main indicators for measuring the phenomenon of 'dispositional feasibility' and, given that these indicators are considered at the highest level of generality via the arithmetic mean, it can only be correlated within the framework of this analytical model. Consequently, this maximum score and the insignificant differences between the remaining indicators of motor-artistic competence determined the almost linear relationship between the correlated arithmetic means. In Camilla's case, a statistically significant but negative correlation between these indicators concerns part 'B' and part 'C'. The remaining correlations, whilst also almost perfect, are not statistically significant (Table 2). However, these almost perfect correlations may lead to erroneous conclusions if, figuratively speaking, one ignores the stabilising influence of Alex's consistently high motivation. In a sense, this approach to the results is justified by the statistically significant differences in the correlation coefficients for Camilla's and Alex's results (although these are calculated separately for each of them on the basis of dependent samples): for part 'A' versus part 'B and 'A' versus 'C'. With a higher value of r for Alex = 0.999 and Camilla r = 0.929, and following Fisher's transformations (2.994 and 1.623 respectively), the difference is 1.371 at p = 3.479, so it is statistically significant at the required 5 percent level. For the r difference between 'A' and 'C' following Fisher's transformations, the values are, respectively: 2.647 − 1.697, whilst the difference of 0.95 (p = 2.423) also meets the criteria for statistical significance.

Notwithstanding these findings, the average marks for Camilla's motor-artistic skills in 'part 'A' and part 'B' place her musical competence at a very good level. In the case of part 'C' however, the majority of marks fall within the upper range of raw scores indicating a good level (from 16 to 20 points). Alex's arithmetic mean marks fall within the range of 17–19 points for the same criterion (Table 2).

The profiles of both pupils, based on the breakdown of these overall marks into percentages and taking their motivation into account, reveal three patterns. Firstly, the mixed marks (motor and artistic) within individual parts of sessions show little variation for each pupil individually. Secondly, the cognitive significance of the mental factor (willingness sufficient to perform a given action) is demonstrated by Camilla's results. An example of this is the fact that standard deviations determined that the previously observed 12 percent differences in the mean scores for declared motivation were statistically significant on one occasion but not on another. Thirdly, a pupil's declared maximum motivation (on the adopted 10-point scale) throughout the entire duration of any music education deprives even the most experienced music teacher of possible pedagogical interventions, not only those directly related to the quality of performance. In the analysis of the empirical data from our observations, the scale of such obvious differences in the motor-artistic competences of the pupils is not the most important factor in cognitive terms, given that the older pupil had 60 months of violin practice behind her at the time of observation, whilst the younger one had only 10 months. What is more significant is the identification of trends that can be explained on the basis of previously discovered laws or established theories (Figure 1).



	force	knowledge & skill	motivation	accuracy
A' Camilla	89	90	67	88
B' Camilla	85	87	79	88
C' Camilla	83	84	91	80
A' Alex	73	72	100	71
B' Alex	76	77	100	75
C' Alex	73	76	100	73

Figure 1. Profiles of pupils based on the most general indicators of 'dispositional feasibility' and 'accuracy', expressed as a percentage of the maximum score (arithmetic means of the indicators rounded to the nearest whole number).

The discovery of these patterns in this study, using a simple tool (a 10-point motivation scale) is a strong indication that the complementary competencies of an instrumental music teacher have greater cognitive and practical value in the long-term strengthening of all dimensions of health than the pressure to achieve musical success as early as possible, regardless of the short-term neglect of important health aspects (including, in particular, mental health).

Motor-artistic effects in various educational contexts

Whilst repeatedly carrying out comparisons for both independent and dependent samples increases the risk of a Type I error, the judicious use of a variety of statistical methods, taking into account certain peculiarities of specific phenomena (or aspects thereof), may prove to be a useful alternative approach. The arithmetic means and the recorded minimum and maximum scores for the movement features (Table 2), are sufficient to conclude that in no lesson was the Camilla's musical effect was not rated 'excellent' in any lesson. Empirical evidence of this is the highest raw score for 'accuracy' of 24 points (which represents 96 percent of this raw score after decomposition). In this situation, theoretically, the highest index of all five measured movement features (i.e. after separating the 'knowledge & skill' components into: 'range', 'tempo' and 'rhythm') is 98.67% (rounded to 99%). This also demonstrates the diversity of factors that influence the quality of musical performance at any given moment during a violin lesson, and that it is not easy to pinpoint the cause of errors. Conversely, the lowest score of 56% for 'force' (14 points), when viewed against the documented motor and artistic competences, indicates that this movement feature was assessed as merely 'sufficient' in at least one lesson.

A detailed analysis based solely on raw results and focusing exclusively on musical and artistic indicators (i.e. excluding motivation and adopting a highly conservative approach), carried out for each of the three parts of the lesson individually and separately for each pupil, reveals that only Camilla exceeded 24 points. This is the upper threshold for the 'very good' level. We have conventionally termed exceeding this figure the 'very good+' level. By contrast, the conservative approach means that even with four maximum marks (25 points) and one 24-point mark – resulting in an

arithmetic mean of 24.8 points (99.2%) – the student does not qualify for an 'excellent' grade. Nor does it matter which of the five movement features this result (level) relates to.

In Camilla's case, we identified two such instances: during part 'C' of sessions 15 and 16. In contrast, the 24.6-point variant occurred three times (98.4%): during part 'A' of session 14 and part 'B' of sessions 15 and 16. We found the highest number (n = 29) of marks indicating a 'very good' level: 13 results during part 'A', 7 during part 'B' and 9 during part 'C' (strictly adhering to the 21 to 24-point range for each mark). Under a liberal approach to marks indicating a 'good' level of motor-artistic competence (n = 14), the distribution is as follows: 2 in part 'A', 7 in part 'B' and 5 in part 'C'. A liberal approach means that the average score falls within the range of 16 to 20 points, but not necessarily the score for any one or any combination of the measured movement feature. Thus, in the first column of the 3×3 table, the total number of 'very good+' ratings is 5; in the second column, listing 'very good' ratings, it is 29; and in the third column, documenting the 'good' level, there are 14 ratings. The value of $\chi^2 = 5.014$, with a required significance level of 5 percent (9.488 for 4 degrees of freedom), does not provide grounds for rejecting the hypothesis of mutual independence between the part of session and the manifested level of motor-artistic competence demonstrated by Camilla, a learner of the violin. In a sense, this conclusion is supported by the relatively low value of the convergence coefficient, C = 0.309.

Alex did not receive a score of 24 points even once for any of the measured movement feature; therefore, in her case, the first column of the 3×3 table contains 'very good' ratings, the second 'good' ratings, and the third 'satisfactory' ratings. The number of entries in the columns is, respectively: 13, 27, 8. Given identical criteria for statistical analysis, with $\chi^2 = 2.913$ and C = 0.239, the conclusion that there is no correlation between the part of session and the level of motor-artistic competence demonstrated by Alex is all the more justified.

The stability of motor-artistic assessments in relation to parts of sessions

The quality of stability in performance, regardless of the level of motor and artistic competence at which it manifests itself, relates primarily to the neurophysiological – and, to some extent, somatic – potential of the young violinist, but also to their current relationship with their teacher. A second important group of factors influencing the quality of this stability consists of events occurring between successive sessions at varying intervals. The teacher no longer has any direct influence over these events.

When we disregard the musical ability of each pupil, the results of the chi-squared test provide two significant pieces of evidence supporting the above assumption. Firstly, for both Camilla and Alex, there are no statistically significant differences in the proportions of marks meeting the criteria for stability – or the lack thereof – across each of the separate parts of the session. Secondly, there are no statistically significant differences in the proportions of these indicators between the two pupils when considering the data for the entire lesson.

Using the same statistical analysis criteria as before, the results for the Camilla and Alex order are as follows: $\chi^2 = 3.718$, C = 0.267; $\chi^2 = 6.155$; C = 0.336.

In accordance with the recommendations of eminent statisticians to reduce R × C tables to 2 × 2 tables were justified, we summed the scores for each pupil individually across the five movement features qualifying for the categories of strict stability and relatively strict stability (where the difference in scores does not exceed 1 point).

Camilla's proportion index is 58.33%, and Alex's is 43.75%. The difference in proportions of 14.58% is not statistically significant: $\chi^2 = 2.102$, with a critical value of 3.84 for 1 degree of freedom and a 5 percent significance level.

Correlations between general indicators of 'dispositional feasibility' and the overall musical effect over time

Since, in these studies, the measure of the overall musical effect is the value of the empirical variable 'accuracy' – derived from 'movement features' – then in reality it is equivalent to the 25-point, intersubjective measure of performance commonly used in Polish art schools (after all, a pupil's termly assessments are based on the verdict of at least three experienced teachers – in this case, of instrumental music). By contrast, the numbering of the sessions from 1 to 16 merely symbolically indicates the passage of time, as the phenomenon is evaluated using an arithmetic sequence with a common difference of 1. However, for example in this study, five days elapsed between the second session (on 6 April) and the first (on 1 April), but only one day between the third session (on 8 April) and the second, only one day passed; it is therefore more likely that during a longer period without direct contact with the teacher, more events may occur that significantly alter not only the musical effects of the session being evaluated, but also the pupil's mental state. In other words, these events are internal or external stimuli that are more or less interrelated. So, when this complete arithmetic sequence of 16 sessions is correlated with the other indicators, the results are, a priori, subject to errors arising from this simplification. Furthermore, there are three further important issues. Firstly, since the stimuli that are the source of these errors are not controlled for, the likelihood of designing meaningful interventions is drastically reduced. Secondly, whilst it is impossible to successfully carry out a statistical procedure to correlate the empirical variables due to the recurring references to Alexis's stated motivation, this does not deprive us of the most general knowledge regarding the mental aspect of her personality. Thirdly, the varying values of the indicators for all empirical variables relating to Camilla do not justify separating the empirical data from part 'C' of sessions 1, 3, 4, 6 and 7, when she was practising 'reading music'. The homogeneity of the data thus achieved in terms of the specific content of instrumental education would also constitute an interference with the model of the passage of time. Carrying out a similar separation in the case of Alex's specific profile – who 'read music' during part 'B' of two sessions and part 'C' of six sessions (5-7, 10, 11, 14) – would constitute a breach of fundamental experimental standards.

Camilla's profile

As time goes by, the indicators of motor and artistic skills show the strongest positive correlation in Camilla's case (an almost perfect correlation), which is, amongst other things, empirical evidence of the effectiveness of the educational process. However, the statistically insignificant, low, negative correlation ($r = -0.252$) between the indicators of self-reported motivation and session number is evidence that, over time, Camilla's emotional attitude towards the lessons she was starting diminished, which had a positive impact on her musical performance (see Figure 1 and Table 2). High correlation coefficients, by that fact alone, do not necessarily indicate a qualitatively high level of the measured phenomena, and vice versa. A good illustration of the ambiguity of these phenomena is, moreover, the barely detectable negative correlations – the highest in the entire observed cycle – between Camilla's motor-artistic assessments during part 'A' and her declared motivation (Table 3).

Table 3. Correlation matrix of the full-cycle indicators for 16 sessions (lessons) with the indicators of the other measured variables during part 'A'.

Variable	No	Variable			
		1	**2**	**3**	**4**
lessons 1 to 16	**1**	x			
force 'A'	**2**	**0.823****	**x**		
knowledge & skill 'A'	**3**	**0.903****	**0.933****	**x**	
motivation 'A'	**4**	−0.252	−0.067	−0.078	**x**
accuracy 'A'	**5**	**0.810****	**0.859****	**0.924****	−0.086

The specific nature of the issue is highlighted even more clearly when these mixed assessments (excluding the data from part 'A' of session 1) with the previously evaluated indicators of Camilla's stated motivation for independent work following the completion of part 'C'. In other words, taking into account the full cycle of 16 sessions, the part 'C' motivation results from the first session are correlated with each individual part 'A' movement features indicator from the second session, etc. and so on, up to the part 'C' of the fifteenth session. This time-shifted correlation of empirical data means that the value of the 'motivation' indicator for part 'C' of the fifteenth session s correlated with the values of the movement features assessments for part 'A' of the sixteenth session. It also makes sense to correlate the 'motivation' indicators of part 'C' with those of part 'A', taking this shift into account.

A negative, statistically significant, high correlation ($r = -0.524$, $p<0.05$) between motivation and musical knowledge and skills supports the interpretation of Yerkes–Dodson law. A very high level of arousal for difficult tasks is not conducive to achieving the most desirable outcomes – in this case, instrumental performance. Furthermore, when applying the criteria of directional testing (which is justified by the documented trend of progressive motor-artistic effects), a statistically significant relationship ($r = -0.524$, $p<0.05$, with a critical value of 0.441 for df 13) exists between motivation and the level of force, as manifested during part 'A', that is commensurate with the expected musical quality. The prognostic power of reducing motivation to an optimal level over time, measured by the R^2 coefficient, increased from 6.35 percent to 14.66 percent. In fact, there is no correlation ($r = 0.039$) between Camilla's motivation indicators and the formula for the shift applied (Table 4), which demonstrates just how sensitive the mental aspect of the young violinist's personality is to the influence – which bears repeating – of internal or external factors not controlled for in these observations, and their interrelationships.

Table 4. A correlation matrix of the 'motivation' variable from lessons 2 to 16 with the indicators of the other measured variables during part 'A', with a separate correlation analysis of the 'motivation' parts 'A' and 'C' in the formula for the shifted results.

Variable	No	Variable			
		1	**2**	**3**	**4**
lessons (from 2 to 16) part 'A'	**1**	x			
force (2 to 16)'A'	**2**	**0.781****	**x**		
knowledge & skill (2 to 16) 'A'	**3**	**0.882****	**0.911****	**x**	
motivation (2 to 16) 'A'	**4**	−0.383	**−0.452^**	**−0.524***	**x**
accuracy (2 to 16) 'A'	**5**	**0.773****	**0.832****	**0.916****	−0.164
motivation (from lesson 1 to 15) 'C'		**x**	**x**	**0.039**	x

A similar analysis of the indicators relating to part 'B' (continuing to play the violin from memory) reveals an almost perfect correlation (r = 0.924) 'force' with 'knowledge & skill' and r = 0.918 'knowledge & skill' with 'accuracy' (Table 5). The correlation between 'motivation' with 'lessons from 1 to 16' is at a similarly low level to that seen in the data for Part 'A' (R^2 = 7.5%).

Table 5. Correlation matrix of the full-cycle indicators for 16 sessions (lessons) z with the indicators of the other measured variables during part 'B'.

Variable	No	Variable			
		1	**2**	**3**	**4**
lessons 1 to 16	**1**	x			
force 'B'	**2**	**0.703****	**x**		
knowledge & skill 'B'	**3**	**0.812****	**0.924****	**x**	
motivation 'B'	**4**	−0.274	−0.190	−0.163	**x**
accuracy 'B'	**5**	**0.745****	**0.885****	**0.918****	−0.086

The time-series correlations of the mean values of the measured empirical variables are based on the assumption that 'motivation' is represented by only that one of the identical statements repeated at least twice which has the highest sum of the mixed movement features scores. An eight-element set of correlated variables was formed, of which the lowest of the averaged values of the motivation declared by Camilla (after decomposing the raw result into percentages) is 53.3% (n = 1). Following the indicator's values in ascending order, the number of identical results is shown in brackets: 70% (1), 73.3% (1), 76.7% (2), 80% (7), 83.3% (1), 90% (2) 93.3% (1).

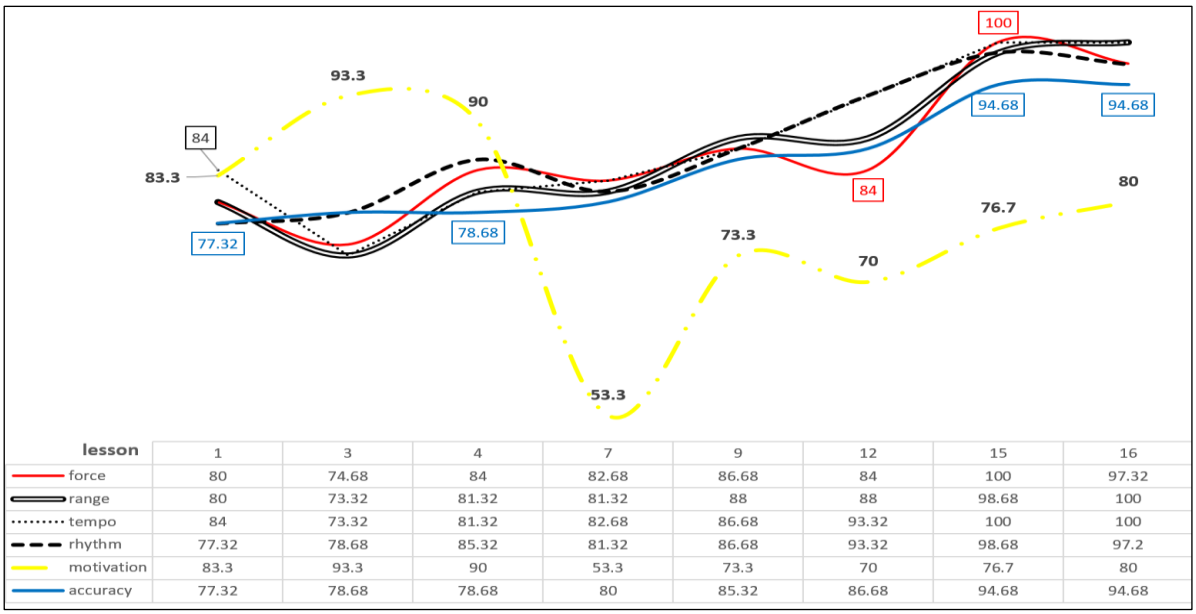
There are almost entirely positive mutual correlations between the mixed-rating indicators. Similarly, most of these indicators correlate with the sessions numbering, even though the difference in the arithmetic sequence no longer maintains regularity (with a value of 1). The positive variable 'force' correlates very strongly with this irregular sequence of sessions (r = 0.871, p<0.01). In contrast, the motivation reported by Camilla over time shows, on average, a negative correlation (r = −0.335, R^2 = 7.5%) and is not statistically significant (Table 6).

Table 6. Correlation matrix for 8 sets of indicators, in accordance with the principle of not repeating identical mean values for 'motivation' (the shaded variables 3 to 5 are components of the 'knowledge & skill' indicator).

Variable	No	Variable					
		1	**2**	**3**	**4**	**5**	**6**
lessons	**1**	x					
force	**2**	**0.870****	**x**				
range	**3**	**0.929****	**0.970****	**x**			
tempo	**4**	**0.905****	**0.915****	**0.971****	x		
rhythm	**5**	**0.954****	**0.894****	**0.931****	**0.971****	x	
motivation	**6**	−0.335	−0.172	−0.219	−0.270	−0.139	**x**
accuracy	**5**	**0.968****	**0.921****	**0.960****	**0.923****	**0.950****	−0.160

Visualising these relationships provides additional cognitive value (Figure 2). Although there is no statistically significant negative correlation over time between the 'motivation' indicator and the other empirical variables, this graphical model nevertheless highlights two issues in a way that figures alone cannot. One concerns

the dispersion of the 'motivation' indicators (yellow line) over time, set against the five indicators of motor-artistic assessment, which are clustered around similar values and show a clear trend of expected positive changes. And yet, almost perfect correlations could also occur in a situation where the motor-artistic assessment scores were very low, yet at the same time very similar. The second point relates to Yerkes–Dodson law. Despite such a large disparity in variability between the 'motivation' indicators over time and the motor-artistic indicators of the other empirical variables, it is evident that a very high level of mental readiness to play the violin in an educational context is not reflected in equally high motor-artistic ratings, and vice versa. Both of these aspects have unique educational value.



lesson	1	3	4	7	9	12	15	16
force	80	74.68	84	82.68	86.68	84	100	97.32
range	80	73.32	81.32	81.32	88	88	98.68	100
tempo	84	73.32	81.32	82.68	86.68	93.32	100	100
rhythm	77.32	78.68	85.32	81.32	86.68	93.32	98.68	97.2
motivation	83.3	93.3	90	53.3	73.3	70	76.7	80
accuracy	77.32	78.68	78.68	80	85.32	86.68	94.68	94.68

Figure 2. A distribution across an irregular sequence of 8 sessions indicators (expressed as a percentage), presented in accordance with the principle of not repeating identical average values for 'motivation'.

Alex's profile

There is a very strong positive correlation between the indicators of Alex's measured motor and artistic assessments during part 'A'. Across the full set of 16 sessions, the positive correlation between 'force' and 'knowledge & skill' is negligible. The 'accuracy' variable correlates only weakly and negatively ($r = -0.192$, i.e. R^2 of just 3.68%) with the session numbering (Table 7).

Table 7. Correlation matrix of the full-cycle indicators for 16 sessions (lessons) with the indicators of the other measured variables during part 'A'.

Variable	No	Variable		
		1	**2**	**3**
lessons 1-16	**1**	x		
force 'A'	**2**	0.019	**x**	
knowledge & skill 'A'	**3**	0.144	**0.723****	**x**
accuracy 'A'	**4**	−0.192	**0.727****	**0.866****

However, it is only when comparing the session for both Alex and Camilla (9 and 15 respectively), as documented by the highest combined scores for the five evaluated movement features, provides the most compelling evidence for the reason behind Alex's inability to maintain, or indeed the deterioration of, her results from session 10 onwards, despite her consistently reporting maximum motivation throughout the observed cycle of music education (Figure 3). Thus, the results presented in this simple model can be justified on the basis of Yerkes–Dodson law; however, it is impossible to explain, on the basis of all the empirical evidence from our systematic observations during this period, whether there is a single or multiple causes for the fact that the pupil so consistently declares mental stability, and at the highest level.

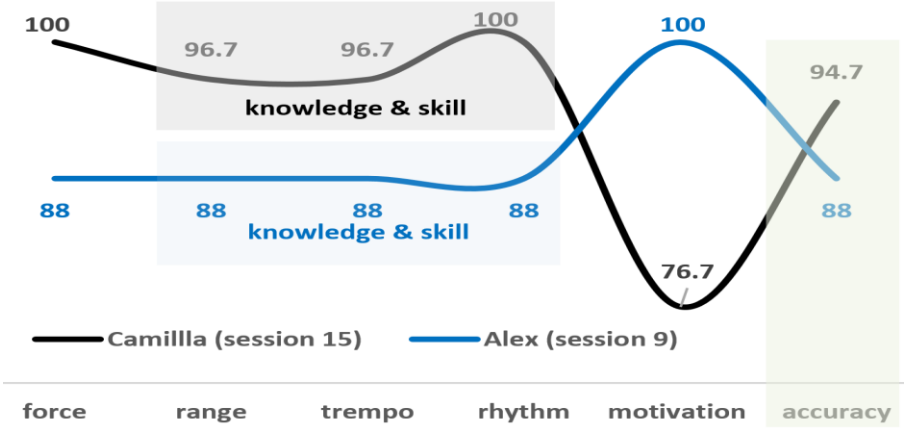


Figure 3. Profiles of the pupils based on for the five measured movement features across all sessions of the observed violin training cycle (each result, expressed as a percentage, is the arithmetic mean of the three defined measurement points).

4. Discussion

A number of coincidences determined the conceptual framework of this research project, as well as the decision to base the empirical component on a case study involving just two girls at the initial stage of their violin training.

Firstly, in 2019, the first author of this paper engaged in a dialogue with the second Expert regarding two factors that link the field of education for instrumental musicians with that of physical education teachers and sports instructors. Two significant conclusions emerged from this dialogue. In Polish music schools, from primary education right through to university level, knowledge of human motor skills (kinesiology) is ignored. Meanwhile, throughout the entire Polish education system, praxeology – the science of effectively achieving the goals of all mental and physical activity – is downplayed [1, 2].

Secondly, none of the teachers who initially expressed an interest in the topic described in this paper met the substantive criteria for inclusion in the next stage of the validation procedure, the aim of which was to identify, from the classification of movement features recommended by Ginter Schnable [37] and subsequently by other experts in kinesiology [38, 39, 53], those suitable for implementation in the field of instrumental music.

Thirdly, after an interdisciplinary team of experts (the first author of this paper and two amateur musicians with academic expertise in the theory and practice of human

motor skills) had identified five movement features (accuracy, force, range, rhythm, tempo), it transpired that these fit within a praxeological, universal model of 'dispositional feasibility'. This is one of the more detailed aspects of the phenomenon of 'possibility of action' [1, 3, 2, 54]. We therefore had to supplement the method of mixed (motor-artistic) assessments with an element of diagnosing the motivation of young violinists to perform tasks at various stages of their education. We used a ten-point scale, and the questions were posed at three points during the observation: before each session, halfway through, and the final measurement concerned a question about motivation for independent practice once the lesson had ended. Paradoxically, there was no need to specify that this referred to work at home, as the observations took place during the first author's own violin teaching practice during the COVID-19 pandemic.

Fourthly, the continuation of remote learning did not eliminate contact between the teacher and the pupils; however, a situation unexpectedly arose in which the First Expert had the opportunity to observe individual lessons. The pupils were unaware of this. He was therefore an anonymous observer in relation to them. Using a commonly available iPhone, he recorded, in certain circumstances, the teacher's verbal and physical interventions, as well as the way in which the teacher documented observational data during the lesson. Immediately after the end of the sessions, in which he participated as an observer anonymous to the pupils, he provided consultations, often making use of the ability to replay and analyse certain episodes repeatedly. It was not possible to involve other instrumental music teachers in these observations due to health and safety restrictions.

Fifthly, given the limited choice amongst the young violin pupils taught by the teacher – there were not enough candidates to form two groups that were homogeneous in some respects whilst differing in others – the arbitrary choice fell on Camila and Alex. At the time, they were separated by a five-year age gap and 50 months' difference in musical experience. What they had in common was that they were both taking violin lessons under the guidance of the same teacher. However, these differences unexpectedly proved to be a factor that enriched the cognitive value of the observations made during the two-month cycle of remote learning.

We did not make the assumption, prior to the start of the observation, that the differences mentioned above were a necessary element. During the period of remote learning, necessitated by the circumstances, the teacher documented the motor and artistic outcomes of the tasks carried out by the pupils in exactly the same way – for each pupil individually. This was a continuation of the random selection method that had been in place for years at the music school whose pupils were observed in this study. What was new for the pupils were the questions asked three times by the teacher regarding their motivation to complete the tasks ahead of them. The nature of remote teaching justifies the hypothesis that most pupils, and perhaps even all of them, were unaware that the teacher was recording their statements as they spoke. It is highly likely that Alex, who was eight years old at the time, was particularly unaware of this. If this hypothesis is correct, it alters the interpretation of Alex's consistent declaration of maximum motivation at every measurement point – the declared maximum enthusiasm will have no impact on her final term mark.

The statement above highlights the significance of praxeology *implicite*, that is, the science which unambiguously distinguishes human action from all other categories of human behaviour. Let us emphasise once again that an action is a purposeful behaviour, and it is only this purposeful human behaviour that is the subject of praxeological inquiry [1, 3, 2, 13] Psychology, on the other hand, deals with all forms of behaviour (including unconscious behaviour). This distinction does not imply a strict separation of the specific tools of these sciences, as is often the case within based on paradigms that examine certain phenomena from different perspectives.

On the contrary, in research based on a complementary approach, this is absolutely essential. A tool as simple as a ten-point scale can be used by any teacher, and not just those teaching instrumental music. However, knowledge of psychology is essential for interpreting the results, particularly when combined with other empirical data (as in the case under discussion). All the more so, therefore, does the involvement of professional psychologists in research projects with similar connections – and documented in collective or individual publications [55-62] – enhance their cognitive value. In pedagogical practice, there is also an element of spontaneous perception of events which, although inspired by recommendations from certain studies, the teacher did not originally include in the programme of their own observations. These events may prove to be fruitful starting points for the future. It does not necessarily have to involve psychological consultations every time.

The analysis of the motor-artistic performance of the pupils over time, based on praxeological criteria (it should be emphasised that this discipline is recognised by those members of the academic community who have studied it and deemed it an appropriate methodology [27, 28, 13, 29-31]) led to the discovery that, halfway through the observed cycle of violin tuition, progress had stalled in a pupil who consistently reported maximum motivation. It is not sufficient merely to explain this phenomenon by reference to Yerkes–Dodson law [63]. The most important aspect concerns the implications for practice. The foremost of these relates to the need for the teacher to undertake an appropriate intervention.

This implication, amongst those articulated in this 'discussion' – to put it slightly differently: a teacher's ability to make appropriate interventions based on innovative, reliably documented knowledge – highlights the significance of the complementary competences of the modern teacher. This paper focuses on the community of instrumental musicians. To put it immodestly, this discovery could have been made by a violin teacher who is proficient in using mixed assessments (motor and artistic) in conjunction with an evaluation of motivation [64, 65]. This is also the formal requirement for basing research on the universal criteria of 'dispositional feasibility'. However, one of the fundamental criteria for such competence is the researcher's awareness of the extent to which, based on their understanding of the circumstances, they are capable of independently interpreting the collected observational data, and when they should seek consultation with experts in specific fields of knowledge. This competence also requires adherence to fundamental ethical criteria in science, if it is to culminate in even a conference paper or a popular science publication: who is entitled to priority for a scientific discovery and legitimate co-authorship.

In the case of these studies, there are many aspects which highlight, at the very least, the need to consult experts even from fields of knowledge that appear, on the face of it,

to be very distant; however, the extent to which individual authors contributed to the final editing of the publication is not so obvious to the reader. We are aware that such knowledge translates into the reader's subjective sense of confidence that all criteria for good research practice have been met. This is an important point, as in circumstances where knowledge of phenomena is accessible from various perspectives (i.e. based on different paradigms), an alternative arises (as in this case: knowledge derived from exploring these phenomena from a complementary perspective); given the objective shortage of music teachers with the interdisciplinary competences associated with this project, it is impossible for an independent team to replicate the research. For the time being, there is an objective obstacle to conducting an *experimentum crucis*. Therefore, irrespective of the formally monitored indicators of contribution, we emphasise that the observational data are the sole responsibility of the first author, whilst the second author carried out an independent statistical analysis of the results. Any uncertainty regarding the reliable documentation of observational data at any stage of the individual education of young violinists should therefore be dispelled.

Another aspect of independence comes to the fore in relation to the joint analysis of the phenomenon of 'dispositional feasibility' by the two authors of this paper. This independence is apparent in the sense that we are divided by differences in expertise and professional experience. However, these have proved to be an advantage in establishing the truth. In these exceptional circumstances, this truth is not some sort of hybrid compromise but a synthesis of well-documented evidence. Alongside the use of complementary theories from seemingly disparate fields of knowledge, the experience stemming from the diversity of personal practices serves as the binding element of this synthesis. Perhaps the simplest and, at the same time, the most striking example is the effect of separating the analysis of the phenomenon of 'dispositional feasibility' between teacher and pupil, whilst – to put it figuratively – freeing oneself from the dominant paradigm of interpreting empirical facts from so-called different points of view (that is, specific scientific disciplines). Therefore, against the backdrop of the findings of an interdisciplinary team of experts regarding motor-artistic assessments and the statistical analysis of the results obtained, we interpret the effect of the aforementioned separation in this way.

(1) A teacher's **force**, in a general sense, can rightly be associated with their physical and mental health (including, in particular, their resilience to any breaches of good behaviour standards by pupils). The force of a pupil learning to play the violin lies in their ability to vary the physical stimuli transmitted to the strings and the fingerboard by the fingers of the left hand, whilst the right hand, using the bow, acts exclusively on the strings.

(2) A teacher's **knowledge and skill**, as illustrated by the broader example of teaching any instrumentalist, are an area of compromise fraught with a paradox. At the basic stage of music education (primary school), the teacher's knowledge is dominant in the relationship with the pupil. However, the teacher should be prepared for the moment when the pupil's skills (measured analytically through motor and artistic assessments such as range, tempo, rhythm) exceed the teacher's own capabilities. The sooner the teacher recognises this and shares this insight with parents and experts – at least within the local community – the more clearly they will demonstrate their very high professional standards and ethical conduct.

(3) Motivation (willingness sufficient to perform a given action) is a criterion which a teacher can apply to a pupil by assessing their engagement at any point during a lesson in a very simple way (such as during the observations carried out for the purposes of this research), but not the other way round – neither the pupil nor the authorised person accompanying them during the session has formal access to such an assessment. Meanwhile, that person is able to make a subjective assessment of the teacher's engagement. Our findings have demonstrated that this element introduces the greatest degree of innovation into the routine process of evaluating a pupil's progress. It goes beyond the narrow focus of formal guidelines on musical outcomes, thereby effectively undermining the teacher's educational mission.

(4) Accuracy is indeed the right word – although the metaphor sounds a bit odd – we 'assigned a role' to this particular movement features, selected from a previously identified set, within the synthetic measure of motor-artistic competence. Together with the others, it is an empirical category with potential applications in a broader context than merely the process of instrumental education, and not limited to violin playing. We have already emphasised in the 'results' section that accuracy is the most general measure of the correspondence between motor actions and the artistic effect achieved, and that it applies both to the piece as a whole and to its individual sections. Consequently, at this stage of education, the teacher serves as the pupil's primary and most readily available model of motor correctness during every lesson, with this correctness verified in real time by the quality of the sound. At advanced stages of instrumental education, the performances of masters, recorded on audio-visual media of the highest possible quality, should be regarded as the appropriate models of precision in the performance of a piece (or its sections). This method is used by coaches in many sporting disciplines, as well as in the training of actors, dancers, mime artists, etc.

Whilst remaining within the methodological framework of the discussion of the results, we would also like to draw attention to the aspect of certain experimental standards being exceeded, albeit unintentionally at first. Even if, in properly designed randomised trials, Alex had been part of a large group of novice violinists, the most important finding of this study – in our view – might never have come to light. There are recommendations from the field of biometrics, illustrated also by graphical models, showing that the rejection of a single outlier drastically alters the value of the correlation coefficient [66, p. 54].

The other side of this most significant discovery is the empirical basis for the hypothesis that it is highly unlikely that a teacher without formal qualifications as a clinical psychologist would make the correct diagnosis as to whether, in cases similar to Alex's, continuing to play the violin is, after all, a form of therapy or rather a form of prevention [67]. However, in the case of Alex's observed educational journey, it is not without merit to link her learning to play the violin with the intense stress constantly manifested in her declarations of maximum motivation. Participation in this education may be taking place under external pressure from a significant figure in the child's life. It cannot be ruled out that the competing hypothesis is correct – Alex's fascination with playing the violin and, perhaps, her visions of a future musical career trigger such deep emotions in her that they become an obstacle to her being able to focus optimally on the motor aspects of musical tasks.

Delving even deeper into the methodological aspects, we notice a certain cognitive link between Alex's case and Tadeusz Kotarbiński's premise concerning conflicts between people, which the creator of agonology classifies as belonging to the 'intermediate level' of generality (in commercial and industrial competition, in a game of chess, in political disputes, etc.) and includes in this set, as he himself emphasises, only the process of upbringing to a certain extent [4, 2]. The word 'to a certain extent' is of crucial importance. For if education is part of upbringing, then the parties to negative cooperation (which, in the language of praxeology, is synonymous with struggle) are the teacher and the pupil. In the most common interpretations, the example given is that the teacher assesses the pupil on the basis of the knowledge acquired, which has been imparted by the teacher and obtained from specified sources, whilst the pupil's aim is to achieve the highest possible mark with the least possible effort. The specific nature of the education of instrumental musicians excludes the teacher and pupil from this model. Moreover, it is hard to believe that Alex would associate the level of motivation with the main criterion for termly assessments. Pressure to raise a pupil's mark most often comes from the parents. We shall not speculate on the reasons for this.

A more significant issue in the field of instrumental music education is the borrowing of terminology from other areas of theory and practice. We are referring to those terms which are not filled with content that corresponds to them in terms of substantive accuracy. An example of this is the part of the title of the book *The Violinist's* **Warm-up**. The motor exercises contained therein, apart from a few remarks on warm-ups in sport, are dominated by musical exercises involving the violin. Instead of first achieving a symmetrical stimulation of all parts of the body in preparation for exertion, the violinist deepens the isolation of the left-hand thumb, whilst the other fingers perform motor manoeuvres on the instrument's fingerboard with varying intensity. Meanwhile, the author rightly observes that '*Once they turn 50, many stage musicians make almost constant use of massage therapists' services; sometimes, they are even under the care of orthopaedists. The most frequent conditions that a musician can encounter are: tendinitis at the base of the thumb or in the wrist, tennis elbow, arthritis of the arms and legs, spinal pain from the neck down to the loins*' [68, p. 16].

This situation – which is, in a sense, the reverse, and not only because of the lack of a direct motor effect – is documented by the results of comparative studies on the subject preferences for bachelor's thesis at faculties of physical education, in relation to the specific nature of the profession the students are studying. At one Polish university, thesis on the biological basis of human development (59.3%) and theory and methodology of physical education and sport (26.74%). At the other university, the figures were: 25% and 26.7% respectively. However, at the latter, other topics predominated (27.27%) followed by the history of physical culture 17.05%. A more detailed breakdown of the data for the first of the universities mentioned shows: anatomy 18.6%, kinesiology 17.05%, anthropology 13.95%, and theory of sport 9.3%. Furthermore, at that university, 3.49% of students chose biomechanics as their subject, whereas at the other university, not a single one did [69]. Whilst studies at faculties of physical education are directly linked to the promotion of all aspects of health, learning to play the violin or any other instrument only appears, at first glance, to have a valid connection to social health and mental health. Intensive manipulation of the hands, particularly the fingers, is of exceptional importance for brain development. It should come as no surprise that the authors of *A scale of weekly*

psychomotor activity from the perspective of personal safety in a complementary framework (WPAS) assigned 3 points to 'playing instruments' on the ten-point WPAS scale, 2 points for participating in school physical education 4 or 3 times, whilst they estimated PE during university studies at 1 point [70].

However, as can be seen from the issues discussed earlier, educational standards can be compromised in various ways. Therefore, as part of our extended collaboration with INNOAGON experts, we have, amongst other things, addressed the issue of incorporating exercises (psychomotor tasks) into the violinist's warm-up that are of fundamental importance in reducing the extreme consequences of accidental falls [65]. The broader scope of this collaboration includes, for example, the participation of the authors of this paper in the validation procedure for the 'susceptibility test for body injuries during a fall' (STBIDF-M) [71]. The opportunity to repeatedly observe simulated falls by the physiotherapy students under study – even when at least one participant in the validation procedure held a differing opinion – also involved learning to carefully identify details of motor behaviour deviating from the defined model. In the case of the STBIDF-M, correct motor responses are those in situations where a person, having lost their balance, comes into contact with the ground. It is obvious that different details are at stake in the motor activity of a violinist, as playing the violin requires conscious behaviours (actions). However, as with any other professional human motor activity, the occurrence of uncontrolled behaviours is part of everyday practice, and not just during the initial period of learning (during training). The key issue for an expert in such training is to determine to what extent such behaviours may affect the ultimate achievement of the main objective.

These examples do not exhaust the multitude of issues that arise at the intersection of instrumental music education and the field of INNOAGON exploration. The cognitive expectations regarding the manipulative abilities of a violinist's hand – whose contribution to the quality of sound production is achieved through the bow – are similar to those of a fencer's hand, which is used to manipulate a weapon during combat [72-75]. Fewer similarities can be found with the characteristics of the dominant hand of athletes of racket sports or batter in in baseball, cricket, softball, etc. [76]. And this preliminary observation implies the need to formulate meaningful research questions for the future. It would be less meaningful to seek somatic similarities and differences between musicians and fencers [77], although it is known that fencers differ in body build from athletes in other combat sports [78-80]. It would be patently absurd to seek, first and foremost, motor similarities between a violinist and combat sports athletes. However, the findings of studies on fencers specifically – simple reaction, choice reaction, movement time, latency, etc., broken down into novices and masters [73] – cannot be overestimated. From a methodological perspective, the following questions would be more valuable: by what methods was knowledge of these phenomena obtained, and is there justification for applying these methods to research on musicians; but also regarding the criteria for designing empirical set-ups using already available equipment to measure the aforementioned neurophysiological phenomena, and even for developing new tools.

We believe that the available research findings – not limited to athletes and not confined to issues strictly related to motor skills – may have an inspiring influence on the implementation of innovative solutions in the field of instrumental music education. For example, knowledge regarding the effectiveness of kettlebell exercises

for American football training [81] is characterised by this very narrow cognitive aspect, but, like other research findings based on a similar framework, it relates to various aspects of health. Since many human activities have a negative impact on health, making a precise distinction between promotion (identified with the certainty that a given activity serves to enhance health), prevention and therapy is the most pressing methodological challenge and requires complementary expertise – and this is the key element of the INNOAGON mission [82-86, 44, 87-95, 67, 96].

5. Conclusions

The most challenging stage in adapting the methodological principles of kinesiology to instrumental music teaching will be the development of criteria for identifying specific 'movement characteristics/movement features' that are accepted and understood by teachers of a particular instrument. The difficulty is all the greater because the basis for such identification is the artistic effect (the arrangement of notes, and often a very short phrase, or even a single sound). This concerns the competence to professionally apply mixed assessments: motor-artistic. This entails drawing on praxeological knowledge, and the problem as a whole points to the necessity of using complementary research methodologies. From two perspectives – methodological and pragmatic – there is an interesting issue that we omitted in this work: 'situational actionability' (the situational possibility of action)..

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