Learning the doublebass: a multilevel approach to the acquisition of motor performance skill

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Abstract: The purpose of this paper is to elaborate on the multiple processes that are involved in the practice and performance of the doublebass. The analysis of movements and skills indispensable to performance will hopefully provide a valuable approach to solving problems that have been related to playing this instrument. By considering some of the basic needs of the physical nature of the instrument and the performer, this work explores playing the doublebass with a maximum of technical ease and economy in order to allow the greatest possible focus on musical expression.
Keywords: doublebass, learning, motor control, pendulum motion, perception, sensory training, skill acquisition, simple and complex movements

Aprendendo contrabaixo: uma abordagem multidisciplinar no âmbito da aprendizagem sensório-motora

Resumo: O objetivo deste artigo é explicar os múltiplos processos envolvidos na prática e performance do contrabaixo. A análise de movimentos e capacidades indispensáveis ao desempenho poderá providenciar uma aproximação importante à realização de problemas, que têm sido relacionados com a prática deste instrumento. Tendo em consideração algumas das necessidades básicas da natureza física quer do instrumento, quer do instrumentista, este trabalho explora a capacidade de tocar o contrabaixo com a máxima eficiência e facilidade técnica de forma a permitir um foco maior na expressão musical.
Palavras-chave: contrabaixo, aprendizagem, controle motor, movimento de pêndulo, percepção, treino sensório, aquisição de capacidades, movimentos simples e complexos.

Introduction: skill acquisition, musical expertise and the doublebass

There is now convincing evidence available which challenges the notion that musical expertise is based on "natural talent." Practice, specific motor skills, and cognitive skills interfaced with instruction and experience are critical elements of expert performance, all of which can apparently be acquired and improved to a professional standard by the most persistent individuals (see LEHMANN, 1997 for a full discussion). Obviously, there are many contexts for learning, ranging from individual intuition to group rehearsal and learning. This paper, however, focuses on the acquisition of performance skills and concentrates on the learning that takes place between teacher and student in a one-to-one context.

Because traditional doublebass schools have excluded an in-depth exploration of the processes of skill acquisition in their methods, my intention has been to propose an alternative approach that is built upon basic studies in the physical nature of both learner and instrument.

Writing about this topic was prompted by my fascination to understand what human motor control and learning has to offer to musical performance, and a mounting frustration as a performer, learner and teacher at not being able to find a textbook which encompasses a discussion of related areas.

1. Motor control and learning

Motor control and learning are the basics of skilled instrumental performance. In the course of learning to play an instrument, a vast amount of coordinated movements has to be controlled and strengthened with practice, forming a motor program which is conceived as a hierarchical structure and that translates information into action (DAVIDSON, 1991). Research has focused on some problems that have been considered influential in motor control and learning in human performance (PROCTOR and DUTTA, 1995); and in the following section, emergent practical approaches will provide a basis relevant to the learning of the doublebass.

2. General background on motor control

> Simply and general stated, motor control is the study of posture and motion and the mechanisms that underlie them. All movements and postures, regardless of quality, are first of all expressions of motor control (ROSE, 1997, p.4).

Contemporary research in the area of motor control and learning (e.g. in the field of sports science) has been trying to understand what is actually being controlled within the human system during the performance of a movement and how the various processes are organized to produce skilled action (ROSE, 1997). BERNSTEIN (1967) outlined his concern about how the performer might be able to control and coordinate a system of the human skeletal systems, linked by joints and the layers of the muscular system in an innumerable variety of planes. The term "degrees of freedom" has been used in order to describe the number of ways in which a given unit of control might be able to move. ROSE (1997) underlines that these units of control may be described in varied terms of joints, muscles or even motor units. PROCTOR and DUTTA (1995) believe that three plans organize selection, coordination and hierarchy, here expressed as the "degree of freedom problem," the "serial order problem," and the "perceptual-motor problem" (ibid. p.102), the three of which are considered below:

i. First, "the degrees of freedom problem" describes how a particular means for achieving a movement goal is selected from the numerous possible and alternative means. In most cases, different ways exist for accomplishing a specific movement so that one of the many alternatives for achieving the desired outcome has to be selected;

ii. Second, the "serial order problem" (ibid. p.104) deals with the sequences of movements in their hierarchy order and timing. When tasks require a sequence of discrete movements, questions of timing and ordering of movements have to be faced;.

iii. Third, the "perceptual-motor integration problem" (ibid. p.104) deals with the interrelations between perception and motor control; in other words, how does perception influence the executed movement and vice versa?

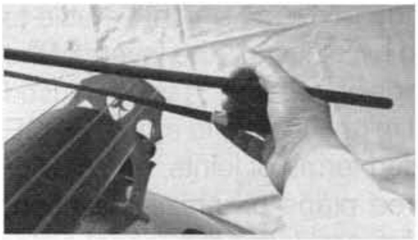
In the following section, I attempt to relate these three "problems" to the doublebass. My proposal leads to a further taxonomy of movements, based on the definitions of skill in a general context of human performance (PROCTOR & DUTTA, 1995).

3. Selection of movements to generate skilled action

> In the performance of any motor act, only one of many alternative means for achieving the desired outcome must be selected (PROCTOR & DUTTA, 1995, p. 102).

To perform a simple action, for example, putting a key into a lock, actions of the limbs involved have the freedom to choose between a vast variety of movements the skeletal system has to offer. These performances are conducted by the intention of the action and environmental factors form the external conditions that have an effect on the performed action.

Following the idea of BERNSTEIN (1967) mentioned in section 2, the vast number of possible combination of movements might be best identified by the degrees of freedom of the involved joints, with one degree of freedom associated to each dimension in which its movements occur. Using Bernstein's classification system, performing a simple down-bow on the D-string, as shown in Fig.1, might involve seven or more degrees of freedom of the right arm-hand system mainly because different limb positions are able to perform the same movement. If the goal is also to perform a constant and linear sound at every part of the moving bow, a vast amount of compensation and combinatory movement of the joints has also to be considered. If the bow arm, in this case, would only offer one position during the performance of the up- or down-bow, it would be virtually impossible to remain with the bow on the string or even be able to produce a superior tone. Thus, the complexity and quantity of movements analysed in the joint space does not seem a very practical way to learn the task. First of all, in order to reduce complexity, the quantity of the degrees of freedom has to be taken to a more abstract level than joint space.



Performing on the doublebass D-string (see Fig.1), the movement is governed by external conditions like the position of the string in relation to the instrument and the bow, and expressive factors that determine the musical purpose (e.g., dynamic, colour and type of skill).

Fig. 1: Performing on the D-string

According to MORASSO (1997), one solution might be to project the trajectory of the arm- hand system towards a three-dimensional space. This author suggests that the planning of the movements, when specified in three coordinates, involves fewer degrees of freedoms than planning in joint space, thus simplifying the problem. Sport science has long described posture and motion of the human body in three-dimensional axis (UNGERER, 1971). Bearing this concept in mind, a three- dimensional frame in order to organize movements in doublebass performance for both left and right hand systems might be proposed in the following way:

In Fig.2a. the activity of the bow arm is predicted by the setting of the four strings (G,D,A,E) defining one dimension. The bow arm has to accommodate to this setting with the ability of the shoulder to act in three dimensions: The transversal (from the front to the back), the lateral (raising the arm away from one's side), and rotational (twisting the upper arm in the shoulder joint). All dimensions of all possible bow and string combinations occur within the circle of the A string (which is the change of the direction of the bow) and the circle of D string (when changing to that string).

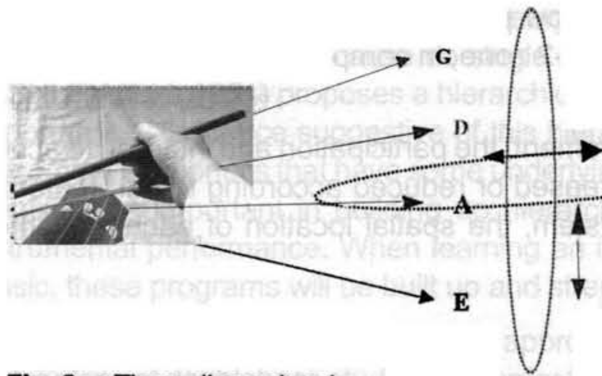


Fig. 2a : Three dimensional space of the right arm

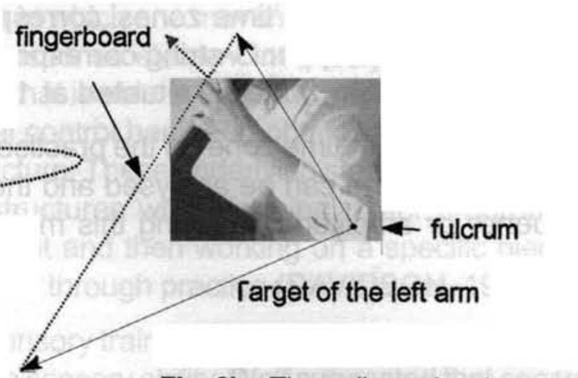


Fig. 2b : Three dimensional space of the left arm

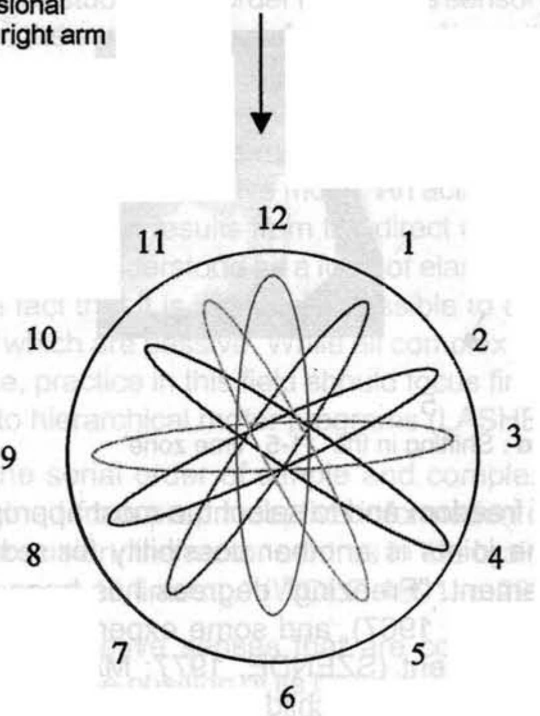


Fig. 2c: three dimensional working space of the rigth and left arm assembling all possible

In Fig. 2b, the target of the left arm is defined by its fulcrum placed near the elbow. Incorporated in one pendulum movement are vibrato and shifting actions with their underlying parameters. The performed movements are similar to the right arm, but here the shoulder has to accommodate to the positions the hand has to assume while placing the fingers on the fingerboard considering all registers. The fingers assume another dimension to access all four strings (see Fig. 2c).

In Fig. 2c and 2d (see the photo below), all movements that are performed from both arms might be integrated in a three-dimensional circle system. In relating each movement to its possible "time zone" of a analogue watch placed in front of the hand like a mirror, it is possible to identify exactly the path of the arm and location. For instance, performing on the G-string corresponds to a motion between eight and two, and the D-string is approximately between nine and three. Applying this concept to the left hand requires that the clock system has to be turned 90º on its side and regarded as three-dimensional. A vibrato movement in half-position affects a 10-4, whereas in second position it might change to the 11-5 zone (Fig. 3c). Shifting of the left hand also might be best performed as an 11 to 5 motion. Trying out every possible combination, it is easy to find out which 'time zones' correspond to bow position or left hand movements. A full bow stroke on the upper G-string corresponds to a 8-2 zone, in comparison to the access of the lowest, the E-string, which is situated at 11- 5.

Depending on the "time zone" of the practised movement, the participation and integrative activity of parts of the arm can be analysed and then increased or reduced according to parameters of frequency or amplitude. Applying this metrical system, the spatial location of each movement

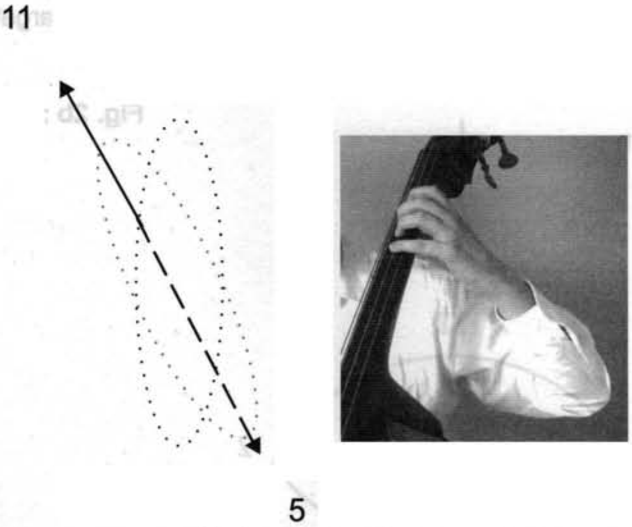


Fig. 2d : Shifting in the 11-5 'time zone'

might help to reduce the degrees of freedom and to select the most appropriate one in practice. Restricting the movements of some joints is another possibility for reducing the degrees of freedom related to a specific movement. "Freezing" degrees has been focused on the early phases of skill acquisition (BERNSTEIN, 1967), and some experimental evidence in musical performance has underlined this statement (SZENDE, 1977; MANTEL, 1987). More recent doublebass methods, especially when applied to children, suggest that the larger movements, or gross skills, should be established prior to fine skills. Performing longer bow strokes may lead more quickly to the basics of technique than shorter ones. Beginning with a left hand position that is located at the visual level of the learner instead of using the lowest positions first is physically less demanding. In this case, sensory experience might be better promoted when using only one position as a reduced working space and somehow freezing the amount of movements. While the limitations of movements are part of the early phases of skill acquisition, these limitations have to be overcome later with the movements of the joints becoming increasingly independent with practice (ROSE, 1997).

While the choice of movements might be applied to single motion, complexity arises when different kind of movements have to be combined, as revealed in the next section.

4. Serial order of complex movements

> When tasks require sequences of discrete movements, some means are required to organize their execution. (PROCTOR & DUTTA, 1995, p.104.)

The "serial ordering problem" concerns how the timing and ordering of the movement elements in sequences might be controlled. LASHLEY (1951), who outlines several approaches, considers that movement sequences might involve sensory feedback in which one movement acts as the stimulus for the next in a series. Because no single action or response element invariably follows another, LASHLEY (ibid.,1951) proposes a hierarchical control that is able to translate information input into performance. Evidence suggestive of this hierarchical control has been obtained in studies using movement sequences that have some underlying structure. These underlying structures have been identified as important in building up hierarchical structures when forming motor programs in instrumental performance. When learning an instrument and then working on a specific piece of music, these programs will be built up and strengthened through practice (DAVIDSON, 1991).

WOLF (1991) developed an analogical approach to sensory training to improve poorly established motor plans of doublebass students. In order to improve sensory ability, Wolf suggested that sensory training has to focus on the various types of simple and complex movements of the involved tasks in order to be effective. Movements can be either simple or complex, when consisting of more than one movement, e.g. closed skills like vibrato, or discrete-continuous skills like detaché bow strokes. In this case, the serial order of complex movements has to integrate the fact that all movements might be performed in an active or passive mode. An active mode serves as a power source of the invested muscular energy and it results from the direct energetic involvement of a muscular pair. The passive mode has to be understood as a form of elastic response to the active one. Confusion might arise due to the fact that it is virtually impossible to distinguish by sight which parts of the motion are active and which are passive. While all complex movements might be performed in an active or passive mode, practice in this field should focus first on active and simple motion before integrating motions into hierarchical motor programs (LASHELY, 1951; WOLF, 1991).

The organisation of the serial order of simple and complex movements is also based on the spatial information gained from proprioceptive information of the muscles: "in order to perform an active mode with precision, the motor centres in the brain and the spinal cord have to 'know' exactly where is the arm at all times..." (WOLF, 1991, p.29).

Wolf refers to the proprioceptive senses that are concerned with perceiving the body's own movement, its location and the position of its limbs in space. This view has been highlighted in the design of sensory learning models in sports (UNGERER, 1977) and ergonomics (OBORNE, 1987). In every day life an individual is able to walk and climb stairs efficiently because of the kinaesthetic feedback that arises from the muscles, tendons and joints used during motion. Thus, it is not necessary to look permanently to one's feet to know where to put them. Similarly, information from the kinaesthetic receptors in the hand, arm and shoulder muscles might allow the musician to use hand-, arm-, and finger control more efficiently and thus reduce muscular tension. Based on the concepts of LASHLEY (1951), WOLF (1991), OBORNE (1987) and UNGERER (1977), the following exercise has been designed as a model to improve sensory ability (Figs. 3a, 3b, 3c.:

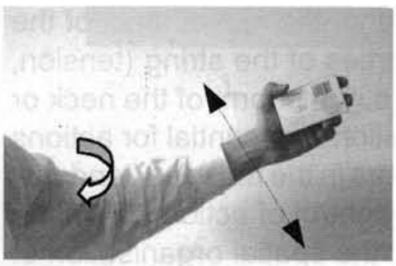


Fig. 3a : Training the active and passive mode

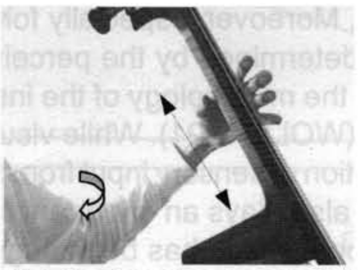


Fig. 3b: Exercise transferred to the instrument

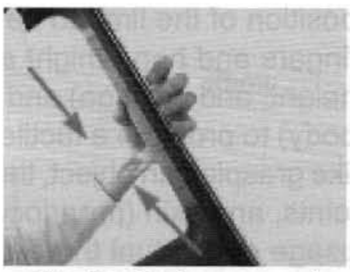


Fig. 3c: Performance of the task

Shaking a matchbox (Fig. 3a) in order to check the contents is a possible approach to experience the performance of active and passive mode. In this exercise, the hand that shakes the matchbox performs the active mode, whereas the rotational movement of-the upper arm, as a result of the previous, is performed in a passive mode. The produced noise of the matches helps to orientate the motion in this stage. In a next step, in order to transfer this movement to the instrument the open hand will swing over the fingerboard, slowly closing it until the thumb and fingers slightly brush over the neck (Fig. 3b). Now the size of the motion has to be gradually reduced to the size of the desired amplitude of motion. The movement adapts gradually to its working position (Fig. 3c). Problems often arise between the 1st and 2nd stage when the motion is produced in a silent mode (without the matches and their aural orientation). This is always a clear sign that the motion is still poorly established. In this case one might have to go back to the first stage.

In summary, the following basic practice guidelines to improve sensory ability on the doublebass should be considered:

i. All movements should be learned as active or passive in order to allow fluency of motion;

ii. Exercises should be designed in a silent mode away from the instrument. Alternative aural orientation should be provided (e.g. match box exercise);

iii. Sensory training models have to act bilaterally in order to establish the desired motor plan and also to replace the poorly established and unwanted motion, normally responsible for tension (e.g. tense vibrato);

iv. Each position, e.g. lower position or thumb position, requires a different angle on the direction of motion. It may be necessary to practice these different dimensions separately.

5. Perceptual and motor integration

> How does perception influence movement, and how does movement affect perception? (PROCTOR & DUTTA 1995, p.105)

The perception-motor integration has been viewed mainly as a bilateral process. Both the perception and motor problem are considered interdependent; in other words, perception has a direct influence on the movement and vice-versa (ibid., 1995). Although it has been largely recognized that perception and action (movement) are mutually dependent, there has been a considerable debate about the way in which they are linked (see e.g. MEIJER & ROTH, 1988). Before a movement can be initiated, relevant aspects of the environment have to be perceived, and the movement itself can also produce additional perceptual information. The characteristics of the environment and the behavioural intentions of the performer might also influence the choice of movements. For example, if the player intends to perform with the bow on a certain string, the trajectory of the movement necessary to reach this position will be a function of the position of the limb to be moved. Moreover, especially for the left hand, the movements of the fingers and hand might also be determined by the perceived properties of the string (tension, height, and position) and also by the morphology of the instrument (e.g. the form of the neck or body) to promote a tactile sense (WOLF, 1991). While visual information is essential for actions like grasping an object, the promotion of sensory input from the receptors in the muscles, tendons, joints, and skin (proprioception), also plays an important role in the control of action. While the usage of a virtual three-dimensional space has been suggested for the spatial organisation of movement for the doublebass (see section 3), another observation regarding the complexity of movement in skilled performance arises and requires attention: the type of movement itself.

When viewing the human body in action, it is evident that pendulum movements are predominant (WOLF, 1991). Ironically, no investigations have considered how useful exploring pendulum movement might be in musical production. Generally stated, all body movements used in doublebass performance might be abridged to the pendulum-based movement, thus following the physical and physiological guidelines which fit well into the proposal made by PROCTOR and DUTTA (1995): Selection, serial order and coordination. Thus a number of mechanical devices describing this type of movement should be briefly considered. As it will be seen, the analysis of physical components will provide some new information about this system and in what type of activities it might be used, especially in regard to efficiency, coordination and economic use of muscular power.

6. Pendulum motion particular for the doublebass technique

All motions, independent of their complexity of execution, consist of simple pendulum-like units in which one end of a limb pivots and the other is allowed to fulfil a swinging or rotating compensatory movement, providing economy and efficiency of motion (WOLF, 1991). Under these conditions, motion supports the initial muscular impulse by swinging in the opposite direction. Pendulum motions are most efficiently used in continuous skills such as vibrato, trills for the left hand and staccato, spiccato and detaché strokes performed by the right (bow) arm. All have the following rules in common:

- They all possess a fulcrum
- All have the ability to swing freely
- They all possess an inherent amplitude that is dependent on the placement of the fulcrum.

A pendulum movement always swings at the inherent frequency independent from the muscular input. This means, in other words, that its periodicity is independent of whether its swing covers a large or small angle. It is, in fact, only at a great expense of muscular energy that it can be forced to act at any other frequency. If the length of the pendulum is altered, then the inherent frequency also changes.

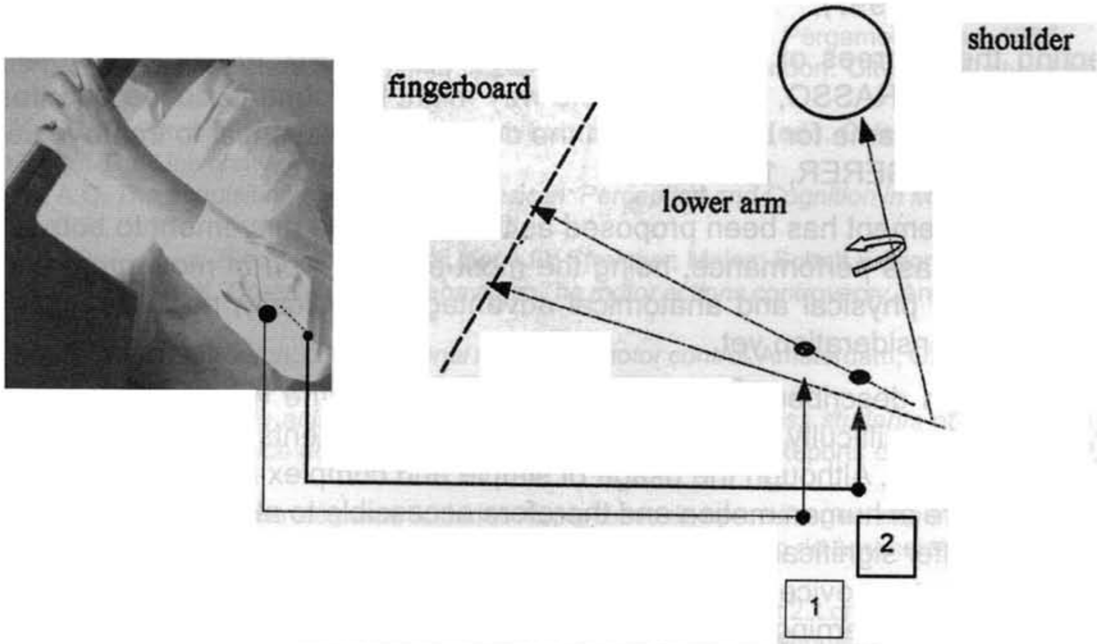


Fig. 4 : The pendulum motion for the left hand

Fig. 4 shows the position of the left hand when performing a continuous skill, e.g. vibrato. The motion of the hand, upper arm and lower arm is transferred into the diagram connected to the photo. When vibrating, the movement of the hand initiates the apparatus of the pendulum motion as an active motion (WOLF,1991). Due to the placement of the fulcrum at position (1) or (2) in the lower arm, every motion performed from the hand and finger provokes a compensatory movement in the opposite direction as indicated, in the form of a passive motion. The frequency of the vibrato might be reduced or augmented by changing the placement of the fulcrum: The movement becomes larger and thus faster when the fulcrum is moved towards the middle of the arm (1) and decreases and slows down when moving towards the elbow (2).

While vibrato is one of the most important tools for expressive performance, this movement schema integrates the basic concept for shifting and mobility, providing access to all playing positions for the left hand, using the same type of complex motion. Repetitive skills like trills and finger placement might well fit into the concept of pendulum motion. The pendulum motion, viewed in a three-dimensional context, might well be considered as a possible overall concept for the production of movements for playing the doublebass. Following determined physical laws, the pendulum movement also provides comprehensive structure that might permit simplification in the selection and in the economy and efficiency of movements. Most of the problems in this area of doublebass playing appear when placement of the fulcrum in correlation to frequency is in disharmony. Trying to force the execution of a motion while it has an inappropriate fulcrum placement will prevent it from swinging freely and is a major cause of undue muscular exertion (WOLF, 1991; PERTZBORN, 1998).

Summary

In summary, as outlined above, skill has been related to motor control, and learning, what leads to the first conclusions of this investigation:

i. The close relationship between posture and motion underlined by Wolf (1991), also mentioned in PRIMROSE (1969) and BARRETT (1974), has been confirmed as one of the essential elements of motor control (ROSE, 1997);

ii. By projecting the degrees of freedom (BERNSTEIN, 1967) of movements to a three dimensional system (MORASSO, 1997), a viable way might be found to define and describe the location and spatial frame for both arms on the doublebass, essential to improve sensory ability (WOLF, 1991; UNGERER, 1977);

iii. The pendulum movement has been proposed as the integrative movement to both posture and motion in doublebass performance, being the most efficient type of movement and thus providing a number of physical and anatomical advantages. Ironically, no investigation has taken this issue into consideration yet.

Movements have been described as either simple or complex; the word complex does not necessarily relate to the difficulty but more to the fact that movements might be composed of more than one movement. Although the usage of simple and complex movement described is based on the repertoire of human motion and therefore accessible to all learners, the quality of motor control might differ significantly. There is no doubt that the amount of instruction and skill-specific practice separates novice and expert performers as they learn to solve a specific motor problem. In observing the learning process of students, very few appear to learn and perform a certain skill in the same way, despite the fact that a group of students may receive the same type of instruction and are provided with the same opportunities of practice (PERTZBORN, 1993-1999). However, each learner is structured differently according to physical parameters such as height, physical build, limb length, muscle strength (stance and stamina) and flexibility. Moreover he/she may also differ in cognitive and perceptual abilities. The combination of the learner-related differences along with the changing constraints of the environment in which the acquisition of skill might take place ensures that the learning process remains complex and challenging for both learner and teacher.

7. Conclusion and outlook

This paper has been written to elaborate on the multiple processes that are involved and which might improve the practice and performance on the doublebass. In the course of performing on the doublebass, the analysis of movements and skills indispensable to performance will hopefully provide a valuable approach to solving problems that have been related to playing this instrument. Traditional doublebass education has proved its merits as well as its limitations. My intention is to focus on these limitations by investigating the multiple processes that are involved in practising, performing and teaching the doublebass. On these bases, the acquisition of skill might be improved significantly.

Considering some of the basic needs of the physical nature of the instrument and the performer, this work explores playing the doublebass with a maximum of technical ease and economy in order to allow the greatest possible focus on musical expression. Indeed, an assumption here is that the principal guidelines of technique are based on efficiency, morphology, ergonomic and economical components.

In the following article, to be published in the next issue of **PER MUSI**, the previously established guidelines will be applied in the process of skill acquisition, thus leading to a way of effective practice.

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