

**THE PHYSIOLOGICAL LEARNING PROCESS  
UNDERLYING THE DEVELOPMENT OF  
LEFT-HAND TECHNIQUE  
IN VIOLINISTS**

by

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This dissertation is submitted in partial fulfilment (25%)  
of the requirements for the Degree of Master of Music.

**SOUTH AFRICAN COLLEGE OF MUSIC  
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**OCTOBER 2004**

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## **DECLARATION**

This work has not been previously submitted in whole, or in part, for the award of any degree. It is my own work. Each significant contribution to, and quotation in, this dissertation from the work, of other people has been attributed, and has been cited and referenced.

Signature: 

Signed by candidate
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*“Violin playing is an exact art...”*

Jack de Wet

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## **ACKNOWLEDGEMENTS**

I would like to thank the following people for their assistance in this research project:

Prof. Jack De Wet, of the South African College of Music University of Cape Town, for his unstinting support, inspiration and guidance throughout my studies.

My supervisor, Dr Morne Bezuidenhout, lecturer at the SACM, UCT, for his time, constructive criticism, and supervision during my research.

Fellow student, Marius Pheiffer, UCT, for all his assistance and insight in the sourcing of information.

My parents for their unstinting support and confidence in my research.

## ABSTRACT

In violin pedagogy, the left hand has often been referred to as the artisan and the right hand the artist of the violinist. This general approach to the playing of the violin sheds light on the importance that must be placed on the development of a sound left-hand technique from an early stage.

This research was inspired by the ideas of one of the leading string pedagogues of today, Prof. Jack de Wet, whose successful synthesis of the science and art of music making is reflected in his teachings.

In this dissertation the relevance of physiological aspects, such as sensorimotor development, is discussed in light of their influence on the basic development of technical aspects of the left hand in violinists. This study endeavours to highlight the role and importance of physiological aspects in the development and transition of the violinist from a “machine for playing the violin” to that of a “machine for making music”.

# CHAPTER 1

## INTRODUCTION

### 1.1. BACKGROUND

Jack de Wet, professor of violin at the University of Cape Town was my first frame of reference to a didactic approach, which fuses the science of movement and the art of music making. He was therefore the initial inspiration and motivating force behind this study.

During my B.Mus. Honours studies with De Wet (between 2000 and 2002), I was encouraged to further investigate and develop my understanding and insight into the impact of physiological aspects on string pedagogy. This led me to attend the University of Cape Town physiotherapy course in human movement in 2001 and also led to interviews and discussions with Marq Labuschagne of the physiotherapy department of the Sport Science Institute of South Africa.

Furthermore, De Wet exposed me to the teachings of pedagogues with similar viewpoints in their didactic approach, such as Paul Rolland. Whilst researching studies made by Rolland during his string project (University of Illinois, U.S.A. 1967-1970), I received video footage of the project from his son Peter Rolland. The footage reflected most remarkably the importance of the project's aim namely that "movement training, designed to free students of excessive tension, can be introduced within an organised plan of string instruction, and will result in faster learning and better performance in all aspects of instruction" (Rolland 2000: cover page). This initial research led to my visit to the Junior Strings Programme run by Penny Sterling (Royal College of Music, U.K.) as well as my attendance of the American String Teachers Association's (ASTA) conference in South Carolina, U.S.A. in 2002. During the conference I was fortunate enough to meet a leading string pedagogue, Gerald Fischbach, whose teaching is largely inspired by his studies with Paul Rolland, as is reflected in his books, *Artistry in Strings* (Fischbach and Frost: 2002) and *'Viva Vibrato'* (Fischbach and Frost: 1997). Dr. Fischbach gave me valuable insights into the importance of Rolland's teaching approach, which advocates physiological conditioning of technical skills of violinists. My discussions with him confirmed what was stated at the 25<sup>th</sup> Paul Rolland memorial symposium, namely that Rolland "knew more about the human body as a violin

playing machine than anyone in the world, and his work is a very scientific analysis of movement”.

My studies to date have led me to the realisation that much research is being done abroad in the field of art medicine in an attempt to fuse the science of movement and music making, not only to avoid occupational injury but also to allow for technical skill and freedom. Very little such research is being undertaken locally. In fact music is one of the last fields of endeavour where the ‘no pain, no gain’ myth still exists. This is the motivation behind this dissertation, namely the need for more detailed understanding and study of the physiological aspects that pertain to the development of musicians skills’.

## **1.2. STATEMENT OF THE PROBLEM**

This study investigates the process of sensorimotor development leading to subconscious atomisation. This is the underlying factor in the learning of skilled left-hand technique in violinists. Grandjean substantiates this by stating that pedagogues need to be aware that the ability to perform a skilled task requires the formation of new reflex pathways for control mechanisms, which function without guidance. The formation of such pathways results in the automatisation of conditioned reflexes (1969: 301). The acquisition of skilled automated reflexes results in a skilled left hand technique in violinists, which in turn allows the musician to focus on musical interpretation. This allows violinists to meet the desired musical demands with which they are confronted.

## **1.3. RESEARCH DESIGN**

The design of this study is qualitative by nature and centres largely round participant observation, which was conducted while attending my lessons with De Wet between 1998 and 2004. During this time I not only underwent tuition myself but also observed and discussed various technical aspects of other students.

Due to the limited nature of this study I have focussed on the left-hand aspects of sensorimotor development. In order to provide a diverse cross section of the didactic approaches pertaining to this area of technical development I have also made a comparative study of the writings of Auer (1980 [1921]), Flesch (1939), Galamian (1985), Rolland (2000) and Fischer (1997), and contextualized them within a physiological framework.

#### 1.4. LITERATURE REVIEW

While much research is being done abroad in physiological aspects of musical performance, this field of research is still developing in South Africa. The isolated nature of such research is evident in the limited number of local pedagogical studies pertaining to this area, which are available at present.

Local studies<sup>1</sup> relating to such pedagogical aspects include Chen's treatise "The Causes and Cures of Mechanical Violin Playing" (1997), which analyses the sociological and psychological aspects of violin playing which lead to mechanical playing. Hough's treatise "Die Tegniek van Vioolspel - 'n Historiese en Metodologiese Studie" (1981) focuses on the historical aspects of technical development of violin playing. Roos's treatise "Violin Playing: Teaching Freedom of Movement" (2001), does in fact provide insight into posture and its impact in violin performance, but does not strive to delve more deeply into the detailed areas of fine motor development.

#### 1.5. LIMITATIONS OF THE STUDY

A limiting factor in pedagogical advancement locally is funding. In contrast, much support and funding is available for pedagogical research abroad. The Teaching of Action in String Playing (Paul Rolland, University of Illinois, U.S.A.) and the Junior String Project (Penny Sterling, Royal Northern College of Music Junior Strings Programme) are only two such projects which have received support from tertiary institutions. These projects allow pedagogues to advance their understanding and insights into didactic approaches and processes in an environment that allows for networking of ideas. In S.A. however the luxury of funding for such projects affiliated with tertiary institutions, is less prominent. As a result didactic advances take place in isolation and do not allow for similar networking of ideas.

A further limitation is the absence of a South African governing string body, such as The American String Teachers Association and the European Strings Teachers Association. The conferences of such organisations allow string pedagogues to reflect upon and share valuable new didactic approaches on a regular basis.

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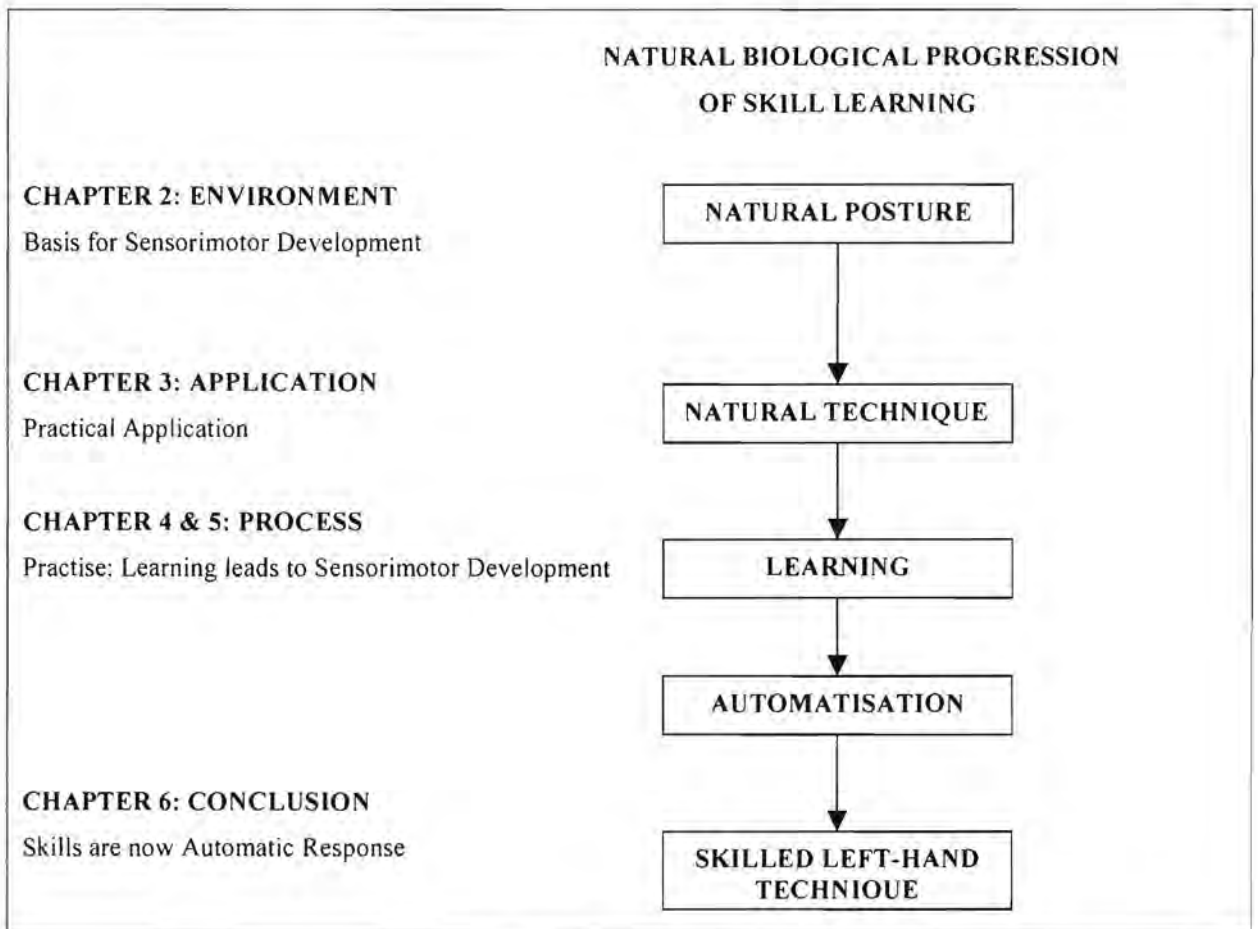
<sup>1</sup> It is important to make mention of pedagogical research by Piet Koornhof, violin lecturer at the Potchefstroom University. This research however focuses on the psychological, as opposed to physiological processes of violin playing. See for example, *The Making of Genius*. 2001. *The Strad*. Vol. 112: 1090-1091, 1093-1094, 1097 and *All in the Mind*. 2002. *The Strad*. Vol. 113: 932-933, 935-936.

Another limiting factor is the nature of pedagogical approaches. In the fields of arts and sports medicine, much research is being done in order to update and discover efficient training regimes and technical approaches. Musicians are however generally quite reticent to adapt didactic approaches in order to fuse scientific aspects with music in favour of a more contemporary approach.

## **1.6. CHAPTER OUTLINE**

Figure 1 provides an overview of the content of the remainder of this study. The progression of the chapters reflects the gradual physiological development of a violin student from the initial posture, to technical skill, which is characterised by automatic responses.

Chapter 2 argues that the basic posture that a beginner violinist assumes lays the foundation for sensorimotor development and should from the outset reflect the physiological requirements for a natural and relaxed posture. Chapter 3 applies this posture and explains its role in the nurturing of a natural technique. Chapters 4 and 5 investigate how these foregone processes relate to the physiological aspects of learning before explaining how the sensorimotor processes involved in learning, lead to automatization. Chapter 6 concludes by reflecting that these processes do indeed lead to a skilled left-hand technique, which is characterised by automatic response.



**FIG. 1. SKILL ACQUISITION: THE LEARNING PROCESS AND ENVIRONMENT**

## CHAPTER 2

### THE ROLE OF POSTURE: A BASIS FOR SENSORIMOTOR DEVELOPMENT

#### 2.1. ASPECTS OF POSTURE

A violinist should develop the fine motor skills of left-hand technique in an environment that promotes a state of muscular balance.

This means that the aspirant violinist must adopt as natural<sup>1</sup> and relaxed a posture as possible while endeavouring to master technical skills in the left hand. A natural posture will enable the violinist to play with - rather than against - the body, and is of prime importance, if an environment conducive to sensorimotor learning is to be created. Once the violinist acquires a natural posture while practising, there will be a conscious but natural development of the sensorimotor facilities, which will reinforce a natural technique. Through consciously directed practice, this process will be integrated subconsciously and result in an automatic skilled left-hand technique.

This state of muscular balance and freedom is the cornerstone in the foundation of further technical development. It is for this reason that the present chapter discusses the ideal posture for violin playing.

##### 2.1.1. THE PHYSIOLOGY OF THE VIOLINIST'S POSTURE

The acquisition of a balanced and therefore natural posture is the foundation of technical skill and efficiency in violinists.

Galley and Foster describe a good posture as a position whereby the "head is balanced and not jutted forward or twisted, the sternum is lifted forward, the knees are straight and not locked and the feet are positioned so that the weight of the body lies to the front and not the back" (1987: 86).

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<sup>1</sup>The term 'natural' refers to the posture that the body adopts when it is functioning without undue tension due to extreme flexion or extension.

The American Orthopaedic Association describes good posture as “a state of muscular and skeletal balance, which in turn allows muscles to function with the most efficiency” (Galley and Forster, 1987: 86). It is this natural state of physiological equilibrium and muscle balance to which violinists strive. Paull and Harrison reiterate this and state that a good posture will not only allow for a natural state of balance and freedom of movement, but will also result in less static tension which may be technically hindering (1997: 53). Rolland too calls for a posture that allows for an “active and flexible” support of the instrument (2000: 68).

The acquisition and understanding of a good posture plays a fundamental role in the efficient execution and development of technical skills in violinists. This is further highlighted by Tursi’s observation that teachers who are ill-informed of a student’s postural requirements may well be responsible for the use of unskilled movements and total failure at a later stage (1955: 6).

Posture is therefore of cardinal importance in the development of left-hand technical skill. The following sections in this chapter highlight the various physiological aspects pertaining to violin technique.

### **2.1.2. THE POSITION OF THE VIOLIN**

Paull and Harrison advise the use of a natural posture when placing the violin. They point out that a successful ergonomic adaptation (such as the positioning of the violin) is dependent on the use of a posture that is anatomically correct, as this will allow joints to function in as neutral a position as possible (1997: 98). In this regard Polnauer refers to Buytendijk’s<sup>1</sup> observation that “the principle of minimal muscular tension generally determines the most natural position or the preferred attitude” (1964: 1).

The use of a poor posture when positioning the violin will lead to excessive tension and anatomical damage. A leading cause of neck disorders is the use of excessive tension when gripping the instrument between the chin and shoulder (Norris, 1993: 24). This gripping action results in tension in the back region, which in turn results in shutting off of free and natural movement in the left limb.

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<sup>1</sup> F. Buytendijk. 1956. *Allgemeine Theorie der menschlichen Haltung und Bewegung*. Berlin: Springer.

Auer notes that the placement of the instrument has a range of possibilities for good or evil and that “there is no instrument whose absolute mastery at a later period presupposes such meticulous care and exactitude in the initial stages of study, as does the violin” (1980 [1921]: 10). Rolland also observes that the placement of the instrument will have an effect on technical aspects such as shifting, vibrato and bowing at a later stage (2000: 61).

Neumann reflects the diverse pedagogical views regarding placement of the instrument in his classification of the two main schools of thought pertaining to this placement. The first includes those pedagogues that advocate the firm hold, which promotes gripping the violin with the head to allow for movement in the left limb. The second school of thought promotes carrying the violin on the thumb and collarbone (1969: 26). Flesch promotes the firm hold in his discussion, which centres on the placement of the violin between the collarbone and lower jaw. He notes that the violin is only supported by the left hand, which must “retain the greatest possible freedom” (1939: 61). Rolland takes a more accommodating stance, claiming that the support of gripping and carrying varies according to the demands of the particular passage in the music (2000: 71).

Neumann criticises the firm hold since it does not achieve what its advocates claim, namely complete relief in the left hand from any holding function. He notes that the loose hold, on the other hand, “relieves the tension of the firm hold, as the addition of the violin weight to the other supporting functions of the left hand remains for all practical purposes imperceptible” (1969: 30).

It therefore seems that the firm hold leads to undue tension and strain, and so hinders technical development, whereas the loose hold deviates least from the natural posture, and so allows freedom and efficiency of movement of the left limb.

### **2.1.3. THE POSITION OF THE ARM**

As Flesch points out, the posture assumed by the violinist’s left arm compels one to “do violence to nature” of a natural position, due to the outward rolling of the left lower arm in the elbow joint. This positioning departs drastically from a natural position (that of the hand hanging next to the upper thigh) and as a result may cause excessive tension (1939: 17).

Rolland considers the violinist's practice of restricting the left hand to the first position in the beginner stages as undesirable. He maintains that this "freeze" of the left arm causes static tension while movement alleviates stiffness and fatigue. By initiating shifting actions of the left arm from the initial stages of left-hand development, excessive tension may be alleviated and balance maintained. This will in turn facilitate a dynamic and mobile left arm action and will alleviate the symptoms of technical strain and injury that may occur at a later stage of the violinist's development (2000: 75).

De Wet validates this by stating that the balance of the left arm forms the basis of a skilled left-hand technique. He says that one should nurture this quality of a balanced arm from an early stage by incorporating circular actions. This in turn results in mobility and alleviates static tension in the arm (1998-2004).

One can therefore conclude that although the left arm posture of the violinist does indeed deviate from the natural posture, tension and stress can be minimised through the promotion of mobility and freedom in the arm, resulting in an optimum environment for technical development.

#### **2.1.4. THE POSITION OF THE WRIST**

Paull and Harrison describe a natural wrist posture as the neutral position that the wrist adopts when making a fist or gripping an object. In this position the wrist forms a supple straight line that does not allow for extreme flexion or extension which may in turn lead to strain. Anatomically this is the position where the wrist functions at its best. In contrast, prolonged playing with the wrist in an extreme posture will lead to injury of the forearm, elbow and hand, hampering further technical development (1997: 82).

Violin pedagogues suggest this natural stance in their discussion of the placement of the wrist in left-hand technique. Galamian writes that a teacher who promotes the principle of a straight-line stance will nurture a posture, which generates freedom and movement in the left hand (1985: 14). Rolland reiterates this by stating that extreme flexion or extension of the wrist should be avoided, allowing only a very slight variation from its natural stance when shifting to and from the higher positions (2000: 106).

These principles realise that a wrist which functions in a more or less supple straight line will allow for a healthy and optimum environment in which a violin student can successfully develop aspects of left-hand technique.

### **2.1.5. THE POSITION OF THE HAND**

The attitude of the left hand of a violinist is largely dependent on the specific technical execution taking place. Although the constraints of this study do not allow for an in-depth investigation into these technical details, one general principle is indeed applicable with regards to the general attitude of the hand. This is the premise that left-hand technique is nurtured through the use of a natural posture, where no static tension exists within the various joints of the fingers and hand.

Flesch points out the importance of an unstrained natural stance by observing that “the position of the arm, fingers and thumb are closely interconnected and interdependent and that one cannot be changed without others participating in the change” (1939: 17). The two main functions of the left hand are to carry the instrument whilst orientating the hand and to elevate the hand appropriately in relation to the neck of the violin. These aspects of the hand are discussed below.

#### ***The orientation of the hand***

The hand should not be allowed to grip the neck of the instrument as this will bring about static tension, which will in turn spread to the entire limb and therefore hinder any skilled movement.

Galamian states that the hand should gently touch both sides of the neck of the violin. If the hand is allowed to gently carry the instrument as opposed to gripping it, the action will allow for freedom of movement and as a result allow the hand to orientate the fingers (1985: 15). Rolland develops this theory further, by suggesting that a beginner should employ the base knuckle of the first finger to touch the neck of the violin, in order to provide a point of contact (2000: 100). It is therefore essential that the aspirant violinist should work with as natural a posture as possible when placing the left hand.

### *Hand elevation*

Rolland states that any unnecessary over or under elevation of the hand in relation to the neck of the instrument should be avoided (2000: 100). De Wet reiterates this judicious use of the fingers by stating that a high placement of the hand will lead to an unnecessarily high placement of the fingers. This will in turn cause the violinist to play on the tips of the fingers and so doing result in a brittle tone production. A slightly lower angle of placement of the hand allows the violinist to employ the sensitive fleshy pads of the fingers and therefore produces a warmer tone quality (1998-2004).

The placement of the hand does therefore not only fulfil the role of the gentle carrying action of the instrument, but also allows for the orientation of the hand in the various positions. Neither of these actions benefits from static tension at any stage. Although hand elevation varies according to physiological build of the violinist, as well as technical restrictions of certain musical passages, the hand posture must never be rigid or strained.

#### **2.1.6. THE POSITION OF THE THUMB AND FINGERS**

##### *The placement of the thumb*

Rolland calls for the use of a natural posture with regards to the position of the thumb. It is in this respect that he refers to the 'native' hand position, as is depicted in figure 2. (2000: 90). When the beginner student's hand is allowed to fall naturally, it automatically adopts the 'native' hand position. This position allows for a space between the 1<sup>st</sup> and 2<sup>nd</sup> fingers (on the D and A string), whilst the 2<sup>nd</sup> 3<sup>rd</sup> and 4<sup>th</sup> fingers lie close together (on the A and E string) (2000: 100). When the violinist's hand assumes this position, the thumb is allowed to maintain an unstressed and natural position. In this position the thumb falls between the 1<sup>st</sup> and 2<sup>nd</sup> fingers depending on the individual's build.



**FIG. 2. THE NATURAL HAND POSITION**

Although the opinions of violin pedagogues vary regarding the placement of the thumb and fingers, none of them deviate excessively from the natural position of the thumb, as is reflected in the following chart:

VIOLIN PEDAGOGUES	POSITION OF THE THUMB AND FINGERS
Flesch	Thumb opposite E natural (1 <sup>st</sup> finger on the d string).
Rolland	Thumb opposite 1 <sup>st</sup> finger.
Auer	Thumb opposite F natural (2 <sup>nd</sup> finger on the d string).
De Wet	Thumb between the 1 <sup>st</sup> and 2 <sup>nd</sup> finger.
Galamian	Thumb between F natural and E natural (1 <sup>st</sup> and 2 <sup>nd</sup> finger on the d string).

All of these postures call for a placement of the thumb that is as relaxed and as natural as possible, since any undue tension can impede any further hand movement.

Flesch states that the role of the thumb is to lightly carry the neck of the violin in its natural position.<sup>1</sup> This natural position is the same position assumed by the thumb during daily life when holding an object; it is neither completely stretched nor bent at an extreme of range, but rather, is slightly curved. This positioning allows for a light touch of the instrument by the thumb and index finger, which in turn allows for freedom of movement (1939: 17).

Galamian warns that any excessive pressure from the thumb results in the paralysis of the functions of the hand. He states that the thumb should not be bent or straight, but rather, should be allowed to rest in a natural position (1985: 17). Although his stance on the exact positioning of the thumb varies slightly from that of Galamian, Rolland also recommends the use of a natural thumb position. A placement of the thumb which is too far behind the index finger will force the index finger to contract, whilst over extension in the opposite direction will force the muscles of the palm of the hand to contract. A relaxed thumb will allow for freedom of movement in the phalanx joints of the fingers, and therefore the thumb should be placed as it falls when at rest, namely opposite the first finger (Rolland. 2000: 105).

<sup>1</sup> See the 'native' hand position as described by Rolland in Fig.2.

### *The placement of the fingers*

Paull and Harrison point out that from a physiological point of view, the finger joints thrive on activity but will oppose being strained or placed under stress at the extreme of any movement. Such extreme action will result in pain, and repeated traumatic attacks of jackhammer action can lead to serious damage of the tendons and nerves in the hand and wrist. The fine muscles of the hands are not made for this type of work, but rather benefit by exploiting fine motor movements (1997: 84).

Regarding finger action, Flesch points out that no excessive movement is required, and that a hammer-like action which knocks the fingers down on to the strings not only hampers tone production but may even result in nerve damage. He promotes no finger pressure as such, but implies that fingers be employed to feel with the pulp of the finger pad in order to attain a relaxed playing posture (1939: 17).

Fischer advises playing with sensitive fingers that are as light as possible. He states that this will allow fingers to feel the 'bounciness' of the string, and therefore avoid dropping them down with a harsh striking action. Furthermore, he speaks of a rolling action of the fingers, which not only utilises less counter pressure than the striking hammer like action, but also facilitates the development of the left-hand vibrato action (1997: 91).

Rolland maintains that the exploiting of these tactile senses of the fingers develops the natural tendency to touch and feel with the fleshy ball of the finger as opposed to the fingertip (2000: 98). De Wet too promotes the use of the pads of the fingers as opposed to the tips. He maintains that the pulp has the greatest sensory potential and that this action will therefore assist the entire sensory feedback process of motor learning (1998-2004).

The placement and action of the fingers and thumb therefore also benefits greatly from the adoption of a natural posture that does not accommodate extreme ranges of motion and tension.

## 2.2. THE OPTIMUM POSTURE REQUIRED FOR SENSORIMOTOR DEVELOPMENT

In conclusion, the following table provides a summary of the natural posture of the left limb of violinists as discussed in this chapter.

TOPIC	OPTIMUM POSTURE FOR SKILLED TECHNIQUE
VIOLIN	Not gripped, but carried on the collarbone and hand, in order to avoid static tension and allow for freedom of movement in the left limb.
ARM	Mobile and flexible with no extreme pronation or supination. Circular actions promote balance.
WRIST	No extreme flexion or extension. Promote the use of a natural position, namely that of a flexible straight line.
HAND	No tension or gripping of the violin. Rather employ the gentle carrying action, which allows for further orientation of the hand and fingers.
THUMB	No gripping or under or over elevation, rather adopt a position that does not deviate drastically from the natural position discussed above.
FINGERS	Employ sensory pads for warmer tone production and more controlled playing. Avoid traumatic hammer actions, which may result in nerve damage.

The common thread that runs through this table is the notion that the optimum posture for the execution and development of skilled left-hand technique of violinists, is one that is as relaxed and as close to natural as possible.

**CHAPTER 3**

**THE ROLE OF POSTURE AND SENSORIMOTOR FUNCTIONS IN THE  
DEVELOPMENT OF TECHNIQUE**

### **3.1. TECHNICAL ASPECTS**

This chapter aims to integrate the previous discussion of posture with various aspects of left-hand technique. This discussion will explore the various aspects of sensorimotor learning, which lead to skilled left-hand technique. The basis of technical development of the violin student will be discussed under the following headings: intonation, drones and natural octaves, shifting and vibrato.

#### **3.1.1. INTONATION**

This section of the study will give a brief summary of the two schools of thought pertaining to the development of sound intonation. Firstly, there are those pedagogues who advocate that intonation is reliant on the hand frame; and secondly, there are those who base reliable intonation on the development of sensory/tactile functions in order to orientate the hand.

##### *The construction of pitch within the hand frame*

Galamian observes that reliable intonation is based on the establishment of a hand position that is focused on double contact<sup>1</sup> with the violin. This hand position is built on a basic frame that the 1<sup>st</sup> and 4<sup>th</sup> fingers adopt when playing the octave interval, as this allows the 2<sup>nd</sup> and 3<sup>rd</sup> finger to function within this frame in a square or extended position (1985: 20).

Although the basic hand frame plays an important role in the structuring of secure intonation, Galamian stresses the importance of the contact of the hand with the violin at all times. He furthermore maintains that this double contact continuously orientates the hand securely and properly, thus resulting in a more secure sense of intonation (1985: 21). Rolland develops Galamian's approach to the hand contact in his recommendation that the grip of the violin should never be allowed to become tense, as this hampers the practise of good intonation (2000: 112).

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<sup>1</sup> The term, "double contact", refers to left-hand contact with the violin, which is maintained by the first finger base knuckle and the thumb.

This contact point of the hand with the violin varies in shifting. In the higher positions (fourth position and up), the lower part of the thumb and hand comes into contact with the body of the instrument, so replacing the contact point of the index finger base knuckle on the neck of the violin. An exception to the above contact points takes place in expressive passages where there might be a momentary relief from the contact point in order to allow for the rotation of the hand, which takes place during vibrato (De Wet, 1998-2004).

Fischer also promotes the employment of a basic hand frame in the process of developing sound intonation. He utilises the principle of memorising the position of the hand, and for this reason recommends that fingers that are resting be kept in close proximity to the string, in order to allow them to judge the spacing of the hand while playing (1997: 186).

Rolland in turn states that secure intonation is dependent on the positioning of a balanced hand. He points out that a balanced hand<sup>1</sup> will allow all four fingers of the left hand to reach prospective notes without injury or strain (2000: 105). One can therefore conclude that intonation in a hand that is balanced will not be hampered by undue strain and tension.

Flesch does not delve too deeply into the technical processes underlying the development of intonation, but does nevertheless point out that “the violinist should never forget that a good sense of hearing is a valuable possession and the most important prerequisite for higher artistry” (1939:21)

This principle of constant contact with the violin in order to establish sound intonation is indeed one that is physiologically sound. Focus on a rigid hand frame does not allow for the development of the tactile functions of the finger pulp. This approach is reiterated by Galamian, who states that sensitive playing and rapid adjustment of pitch is dependent on the utilisation of a gentle sensitive action of touch (1985: 22).

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<sup>1</sup> This refers to the natural posture that Rolland discusses in his reference to the ‘native’ hand position in Fig. 2.

### *Tactile construction of pitch*

The development of technical facility, which allows for rapid adjustment of pitch, is based on the development of the hands tactile perception, which is far more reliable and accurate than that of the hand frame.

It is important to note that manual recognition and construction (sensory perception) is a quality that can indeed become highly developed in violinists, if it is exploited. An example of this sensory development is noted in blind individuals who compensate the loss of visual sense by a heightening of their tactile senses. This would probably account for the description of the hand as the "second eye of the body" (Galley and Forster, 1987: 220). This testing function of the hand and sensory application is vital to the development of technical skill in the left hand of violinists.

This emphasis on the hand's tactile perception as regards to good and secure intonation has a sound physiological basis. Galley and Foster point out that the hand is the most highly developed sensory organ and chief organ of touch in the body. Furthermore, they observe that hand movement is controlled and directed by the sensory system and that the impact of these sensory functions of the hand can be assigned to its large area of representation in the motor cortex of the brain (see Fig. 5.2.) (1987: 220).

The following table is an adaptation of Galley and Foster's discussion of the physiological processes underlying the tactile aspects. It furthermore reflects the importance of sensorimotor functions in the development of intonation (1987: 220).

PHYSIOLOGICAL PROCESS OF TOUCH	APPLICATION TO INTONATION
At first the contact with the object being touched is superficial. This initial contact provides coetaneous sensory information.	The initial contact with the neck of the violin is made between the thumb and the base of the first finger. This initial contact orientates the hand.
The contact increases in depth as the hand feels and explores the object, providing deep coetaneous impulses from the pulp of the fingers and hand, as well as proprioceptive <sup>1</sup> sensory impulses from the muscles and joints to the cortex.	The pulps of the fingers “feel” the strings. Coetaneous impulses and proprioceptive feedback, together with auditory sensations, construct an image of the desired pitch being practised in the cortex.
A mental image of the object is formed, according to its shape, surface, dimensions and pattern.	A sensory and auditory concept of the pitch is constructed and regulated by means of sensorimotor feedback loops.
This results in the shape, size and strength of the grip being determined, which will in turn be altered according to the demands of the movement.	Feedback loops allow for rapid adjustment in the hand to take place. This is done in order to meet the criteria of the sensory “image” of the pitch, which is constructed in the cortex.

In the table above, the discussion of the function of the hand creates an understanding of the establishment of left-hand technique in violinists, in this case specifically intonation. From the discussions above one can conclude that a focus on the basic frame of the hand and hammer like action in correcting intonation delays the process of correcting pitch, as it relies heavily on the conscious directing of movement. However, exploiting the sensory function of the hand heightens the reflex of correcting pitch before the note is already sounded. Thus intonation becomes a reflex, a subconscious process, which is acquired through a process of sensorimotor development. Labuschagne points out the sensory receptors of the hand can become highly sensitised and developed through practise (2004). As a result the skilled violinist evolves to the point of actually ‘seeing’ and ‘hearing’ by means of the sensory receptors in the fingers.

<sup>1</sup> These are receptors that receive impulses that occur because of body movements or position. They are responsible for transmitting a constant flow of information from these structures to the central nervous system (Luttgens and Hamilton, 1997: 85)

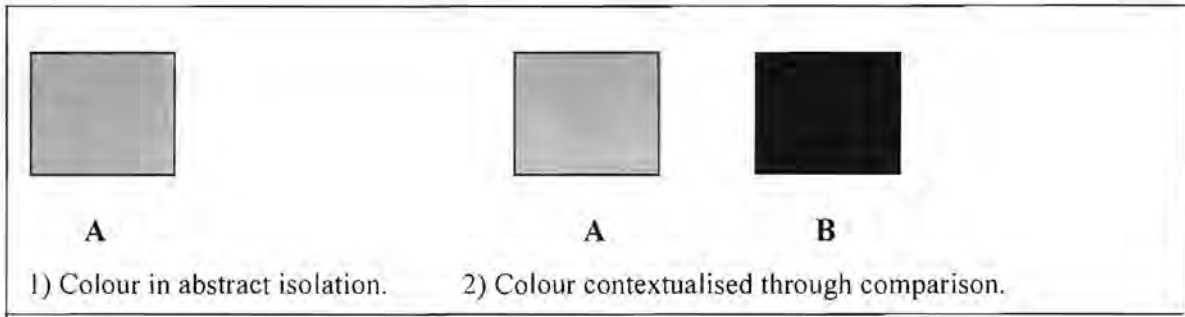
### 3.1.2. DRONES AND NATURAL OCTAVES

The topic of double-stops in itself pertains to a wide field of left-hand technique. The following discussion will aim to shed light on the general physiological processes and requirements for the further development of the various forms of double-stopping. This section of the study does not discuss the traditional double-stops (thirds, sixths, octaves and tenths) but rather details the use of natural octaves (this entails the playing of octaves where the lower pitch falls on the open string) and drones as the foundation which will allow for the further development of double-stops and intonation.

De Wet points out that the use of drones and natural octaves are not only necessary for their specific application in musical passages but are indeed also a vital cornerstone in the further establishment of secure intonation and the sensory development of the hand. It is of the utmost importance that beginners are exposed to their first concept of double-stopping from an early age, as a true establishment of the concept and correcting of pitch cannot exist or be developed in the vacuum of an abstract single note. De Wet notes that a young beginner will only be able to adjust the pitch of a note once it is heard in a harmonic context, namely by comparing it with the pitch of another note. Rolland reaffirms this by suggesting that students employ the use of the natural octave. (2000: 102). Another application of the natural octave is De Wet's use of the drone note in the early stages of development. This involves the playing of the open string while other notes are played simultaneously on the neighbouring string (1998-2004).

The principle of comparative feedback in the construction of the violinist's pitch concept is clearly understood when one applies it to a young student's concept of colour. The intensity of a specific shade of colour is not understood in isolation. It is only understood when it is placed in close proximity to another colour of differing intensity. Once it is compared its intensity becomes a concrete concept.

This concept is depicted in the following example, whereby a student only understand the intensity of the colour in block A once it is placed in next to, and compared with the colour of block B.



**FIG. 3.1. INTONATION: CONCEPTUALIZATION OF PITCH BY COMPARISON**

In violin playing this comparative feedback (which takes place on a sensory as well as an auditory level) results in the sensory systems making the necessary adjustment between the presented pitch and the desired pitch.

The initial introduction to pitching of two notes within a harmonic as opposed to a melodic context is an important point of departure for a natural and healthy left-hand posture. It is also the first stepping-stone in establishing the student's auditory conceptualisation of intonation and further development of the various forms of double-stops.

### 3.1.3. SHIFTING

Neumann discusses the roles of the various positions to which shifting takes place under the categories of the chromatic and the diatonic positions. He explains the various positions as guide posts, which serve to orientate the fingers (1969: 75).

This orientation takes place by means of sensory impulses<sup>1</sup> received from the pulp of the fingers during shifting. This chapter will not focus on the technical details pertaining to shifting, but rather on the process of shifting. This will be discussed in light of the underlying sensorimotor processes that are developed by the aspirant violinist during the learning process.

<sup>1</sup> See chapter 5: sensory impulses (proprioceptors).

Galamian categorises shifting into two classes, namely complete and half shifts. He describes the *complete shift* as a shifting action involving the entire hand (the hand, thumb and all the fingers move into the new position), whilst the *half shift*, requires that the hand remains anchored (the hand and fingers move up or down into other positions by bending and stretching). He outlines the importance of avoiding unnecessary shifting by pointing out that the half shift can be used in many instances where the finger has to move into another position for a few notes only. He also notes that when properly applied, the half shift can greatly promote facility and security in passages that would otherwise be very cumbersome (1985: 24).

The following figures present a summary of Galamian's reference to the various forms of shifting (1985: 25).

During the execution of the *basic shift*, the same finger plays the note preceding and the note following the shift.



FIG. 3.2. THE BASIC SHIFT

The following example represents the *classical shift*. In the performance of the classical shift the finger that is on the string when the shift starts performs the shift, but a new finger plays the arrival note.



FIG. 3.3. THE CLASSICAL SHIFT

In the execution of the *romantic shift* the finger that will play the arrival note performs the shift.



FIG. 3.4. THE ROMANTIC SHIFT

The following example represents the *retarded shift*, a much-used type of shift today. This shift requires a combination of the classical and romantic shift. The finger is firstly stretched to a new note outside of the position in which the hand is resting at the moment, and after the stretched finger is placed on the string, the hand follows thereafter into the new position.

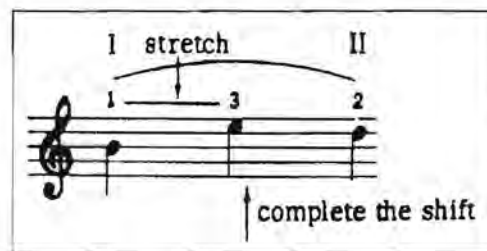


FIG.3.5. THE RETARDED SHIFT

According to De Wet the use of the half shift (as far as possible in order to avoid any unnecessary shifting) is far more desirable from a physiological point of view. This uninterrupted contact with the instrument allows the thumb to rotate, and in so doing is able to supply further sensory “feedback” messages to the sensorimotor areas of the brain (1998-2004). Furthermore Magill notes that a chain of sensory feedback,<sup>1</sup> which relies on constant contact, is far more effective when learning new physical skills. It is this sensory feedback that constructs the information that leads to skilled motor learning. Continuous contact with the string allows for more receptive impulses to be fired, which in turn supplies the necessary sensory information to the brain which enables it to formulate an appropriate plan of action.

<sup>1</sup> See Feedback Loops (5.1.3), Chapter 5.

This plan of action is then communicated to the muscles needed to perform the specific technical skills required. This in turn allows them to execute a specific set of musical skills (1998: 39).

Rolland portrays the role of the sensory impulses in these various shifts by stating that in order for a smooth and efficient shift to take place, the arm should lean in the direction of the shift before the finger is released from the old position. He describes this action as being similar to the action of walking, in which each step is begun by leaning in the direction of the movement before the foot is lifted off the ground. He ascertains that this leaning motion eliminates inertia of the arm, which should never be held rigidly, but should always be relaxed. (2000: 38)

From the discussion it is clear that shifting which relies on sensory perception and feedback as opposed to rigid and unnecessary position changes is far more desirable.

#### **3.1.4. VIBRATO**

Vibrato consists of a rapid oscillation of pitch on a specific note, and is used to give tonal colour and warmth to the music being performed. Various schools of violin pedagogues have argued that vibrato is best achieved through the arm, hand or fingers. It is important to realise that no part of the body works in isolation, and therefore a natural body posture, which takes all muscular movement in consideration, is the most logical alternative in establishing a secure and versatile vibrato.

As Neumann points out, the study of vibrato is probably the most involved and controversial topic of left-hand technique (1969: 111). He notes that the main controversy among leading pedagogues with regards to the vibrato centres on the question of whether it should be produced by the finger, the hand or the arm (1969: 117).

Any approach, which advocates the use of a specific limb in isolation, is doomed to failure - vibrato should be achieved through an integration of total body actions. This is reflected in Rolland's observation that the driving force of vibrato stems from the muscles of the hand, forearm and even the shoulder. He proposes that the prerequisite for a good vibrato is a balanced left hand. He notes that individual players show a variety of ways of combining the movements of the finger, hand, forearm, and upper arm. He sums up this notion by stating

that the violinist should strive to attain a beautiful sound through the production of efficient motion patterns with the least possible effort (2000: 153).

Galamian states that the developed vibrato may be centred either in the arm, the hand, or the finger. He also states that if there is no stiffness to prevent it, each vibrato type will normally bring about interplay of the neighbouring muscles and therewith introduce elements of the other two types. He notes that within each of these three types, speed, width, and intensity can be varied to a fairly great extent, which gives the violinist the freedom to draw on all three types if s/he is to display perfect vibrato control. Furthermore he reiterates that a player thus equipped is in a position to colour the tone exactly as s/he feels it ought to be coloured in any particular instance. He concludes that once the vibrato is truly mastered in all of its aspects, the practical control becomes subconscious and spontaneous - from the 'white' sound of non-vibrato to that of the greatest intensity. The arm vibrato is the most intense, and the finger vibrato the most gentle (1985: 38).

Galamian summarises the role of the various aspects of vibrato as follows:

"The combining of all of the types of vibrato with all of the dynamic nuances and shadings of which the bow is capable can result in an endless succession of possibilities for giving life, colour, and variety to a violinist's performance" (1985: 37).

De Wet argues that the isolation of vibrato in the arm, wrist, or fingers, may lead to undue tension in neighbouring muscles. This in turn will result in a laboured inefficient vibrato. Once again as with other left-hand technique, initiating the vibrato impulse with a flatter finger brings about forearm rotation and utilisation of the back muscles. This allows for continuous fine motor feedback by the receptors in the finger pulp, which in turn allows for more rapid and accurate adjustment of the vibrato where needed (1998-2004).

By allowing the hand to work in conjunction with the arm and fingers, the hand will be brought to life, resulting in continuous and cantabile tone production and a more sensitive performer. In light of this it is understood that by integrating arm, hand and finger actions which compliment and support one another, the violinist will be able to assume a natural body posture, which will in turn nurture a natural vibrato.

## CHAPTER 4

### THE APPLICATION OF SENSORIMOTOR FUNCTIONS IN THE DEVELOPMENT OF LEFT-HAND TECHNIQUE

#### 4.1. THE LEARNING PROCESS

The preceding section depicted skilled left-hand technique as being dependent on sensorimotor development, which takes place within the constructs of a natural posture. This chapter reflects on the role and application of this sensorimotor development in the learning process.

##### 4.1.1. THE STAGES AND INTEGRATION OF LEARNING

The following quote by Parncutt and McPherson gives a vivid summary of the process and culmination of skilled motor learning.

“The precision, range and variation of the movements responding to the will of the seasoned player are acquired through a process of painstaking perceptual and motor learning. Those of the virtuoso performer appear to flow in a succession of exquisitely timed and effortless sequences that yield a singing tone amenable to limitless diversity in quality and connotation” (2002: 63).

A violinist acquires technical skill, grace and ease through a constant process of learning - a process, which evolves from the initial stage of conscious direction of motion and sensory stimulation to the final stage of subconscious skilled motion. During the transitional phase the constant guidance of the teacher is important, as it is here that technical faults, difficulties and injuries tend to arise. Morehouse and Cooper observe that the initial stage of complex movement is constructed by continuous attention to visual, tactile and proprioceptive sensations and that the highest level of skill is only achieved after conscious effort has been eliminated (1950: 210). This is confirmed by Palmer and Meyer whose research suggests that the mental plans for actions only become independent of the required movements at an advanced skill level (2000: 63). A clear understanding of the learning process is essential if skilled technical facility of the violinist is to become a focused subconscious reaction.

The following figure is an adaptation of Galley and Forster's description of the three stages of the learning process (1987: 107).

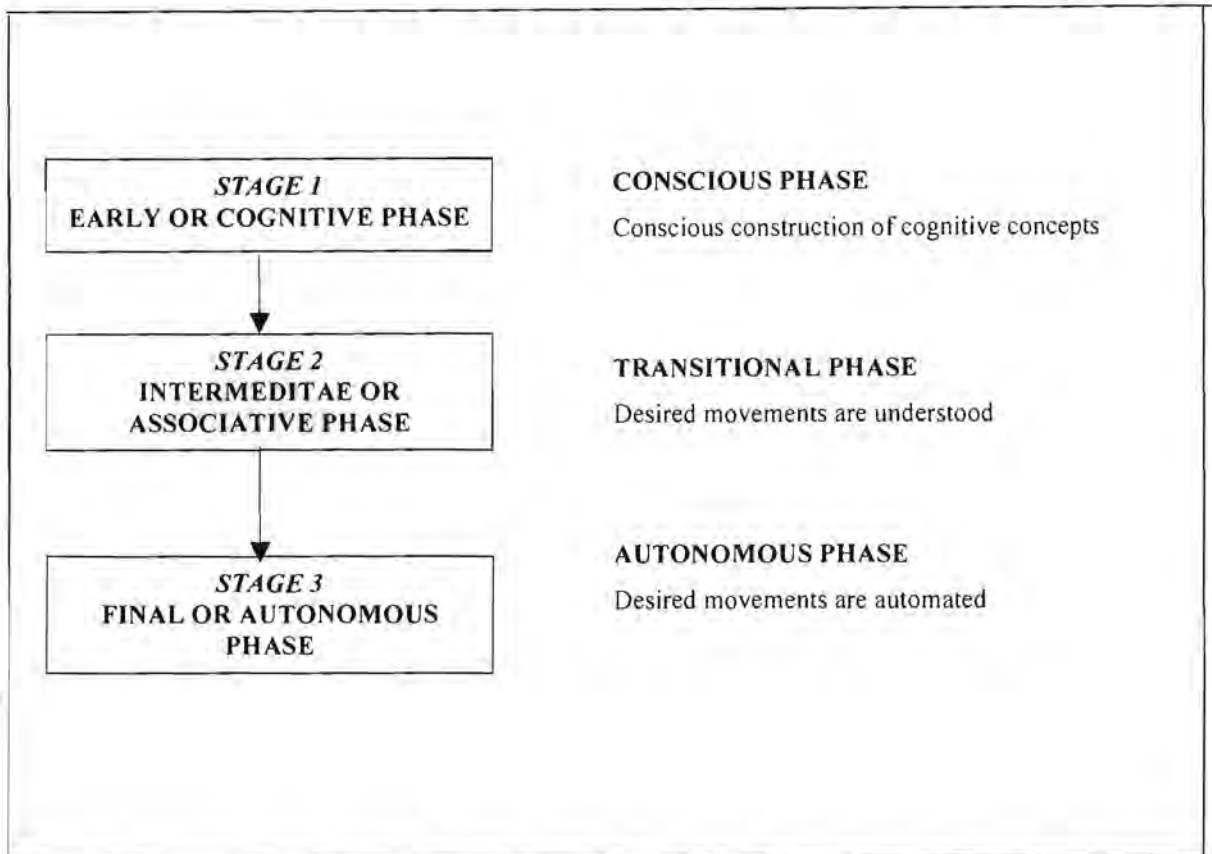


FIGURE 4.1. THE NATURAL PROGRESSION OF THE LEARNING OF SKILLED MOVEMENT

The *early cognitive phase* is the initial stage of learning where movement is assimilated. Although acts at this stage are initiated without directing the results, the teacher can nevertheless greatly influence the rate at which the specific conscious direction of physical acts being practised is relinquished. During this stage the student identifies and tries to understand what the new technical process requires. At this stage of learning great attention has to be paid to cues and suggestions from the student's environment. The teacher plays a vital role in this early conscious stage, as feedback<sup>1</sup> is of the utmost importance in helping the pupil to structure his/her future sensorimotor behaviour.

<sup>1</sup> See chapter 5: Augmented Feedback (5.1.3).

In the *associative phase* an association is made between the cognitive understanding and physiological execution of the required action. This phase can last for varying periods of time; however with constant, diligent and goal directed practice, skilled movement can be consolidated and established with errors gradually being eliminated. It is during this phase that sensory receptors start to build reflex pathways for automated re-actions (Galley and Forster, 1987: 107).

During the final phase, the *autonomous phase*, skills evolve automatically. This is an extremely advanced phase where the activity has become so well learnt that attention can be diverted to the events occurring in the environment without the performance being disturbed. It is only during this phase that the learner's performance can be truly described as skilled and automated. Van Lehn describes automated processing as fast, effortless and autonomous (1996: 531). Once the term 'skill' is used, the implication is that learning has taken place. Skilled behaviour is intentional, has purpose and is goal oriented and flexible (Galley and Forster, 1987: 107). Rolland notes that it is at this stage that the "machine for playing the violin" becomes a "machine for making music". He develops this further by stating that "musical ideas replace technical directives, and the student becomes preoccupied with these objectives, as the machinery of the living body cannot attend to both simultaneously" (2000: 107). Palmer and Meyer make the importance of this phase of musical development clear in their observation that mental plans for actions only become independent of the required movement at an advanced skill level (2000: 63).

In conclusion, an effective learning process culminates in physiological automatisation. The failure of the teacher to give constant guidance and insight to the pupil during these formative phases of learning will impede and hinder the pupil's attempts at synthesising information and establishing automated sensory pathways. The sensorimotor process of learning does indeed relate to the acquisition of conditioned reflexes in the left-hand technique of skilled violinists. The significance of the various learning phases is reflected in the following summary of the characteristics pertaining to skilled learning. These are the characteristics to which the pupil, with the guidance of the teacher, should strive towards during the learning process.

#### 4.1.2. THE CHARACTERISTICS OF LEARNING

Magill states that once effective learning has taken place there is a definite change in the capability of a person to perform the skill. This capability is understood as a permanent improvement in performance, due to practise or experience (1998: 129). It is essential that violin pedagogues have specific criteria to monitor and guide the learning process, as this will enable them to determine whether the teaching, support and guidance are effective.

Magill provides the following criteria as a means of assessing the level of skills that a pupil has mastered.

**Improvement:** Performance of skill should show improvement over a period of time. The learning process, which is based on automatisation, encourages the pupil to add to the existing cognitive structures of skills, thereby increasing the repertoire of possible skilled responses between the brain and sensorimotor receptors. Some musicians refer to the characteristic of improvement as the “building of technical facility”. Teacher support is important if constructive learning is to take place and faulty motor habits eradicated. This is reflected in Magill’s observation that “practise can result in bad habits and performance failure at a later stage” if the pupil’s progress is not constantly monitored (1998: 129).

**Consistency:** A learning process that leads to automated reflexes at a later stage will reflect a progression of learning, in which performance becomes more consistent (Magill, 1998: 129). Labuschagne points out that learning that employs only the early phase of conscious direction is easily influenced by environmental factors which may vary, and therefore greatly impact on the execution of skilled movement (2004). This consciously directed movement alone does not allow for consistency.

**Persistence:** Magill describes this characteristic as the improvement of skill performance capability over an increasing period of time... “an important characteristic of skill learning is that a person who has learned a skill should be able to demonstrate the improved level of performance today, tomorrow, next week, and so on”. He concludes that ‘persistence’ characteristics relate to a relatively permanent improvement in performance (1998: 129).

*Adaptability:* Finally, successful skill performance requires adaptability in a variety of performance settings. Such adaptability allows for changes in personal, task, and/or environmental characteristics. The degree of adaptability required depends on the skill and the performance situation. As a student progresses in learning a skill, the capability to perform the skill successfully in these changed circumstances also increases (Magill, 1998: 129).

In conclusion, in order for a violinist's technical skill to be developed, left-hand technique has to be nurtured in an environment that leads to automatic reaction. Such automatic reaction is acquired through a learning process that relies on building reflex pathways that are initially consciously directed, but through practice become an automatic response. Skilled left-hand technique is a process, which relies on automatic reactions that reflect the characteristics of improvement, consistency, persistence, and adaptability.

#### 4.1.3. THE INTEGRATION OF SENSORIMOTOR FUNCTIONS DURING THE LEARNING PROCESS

Figure 4.2. , below, is an adaptation of an illustration by Galley and Forster. It depicts how a student's skill in performing certain technical tasks is measured by the performance time taken to execute the required acts. This is done by calculating the *reaction time*, which is the time taken from the presentation of the signal until the beginning of the movement response, and the *movement time*, which is the time taken to complete the desired movement program (1987: 103).

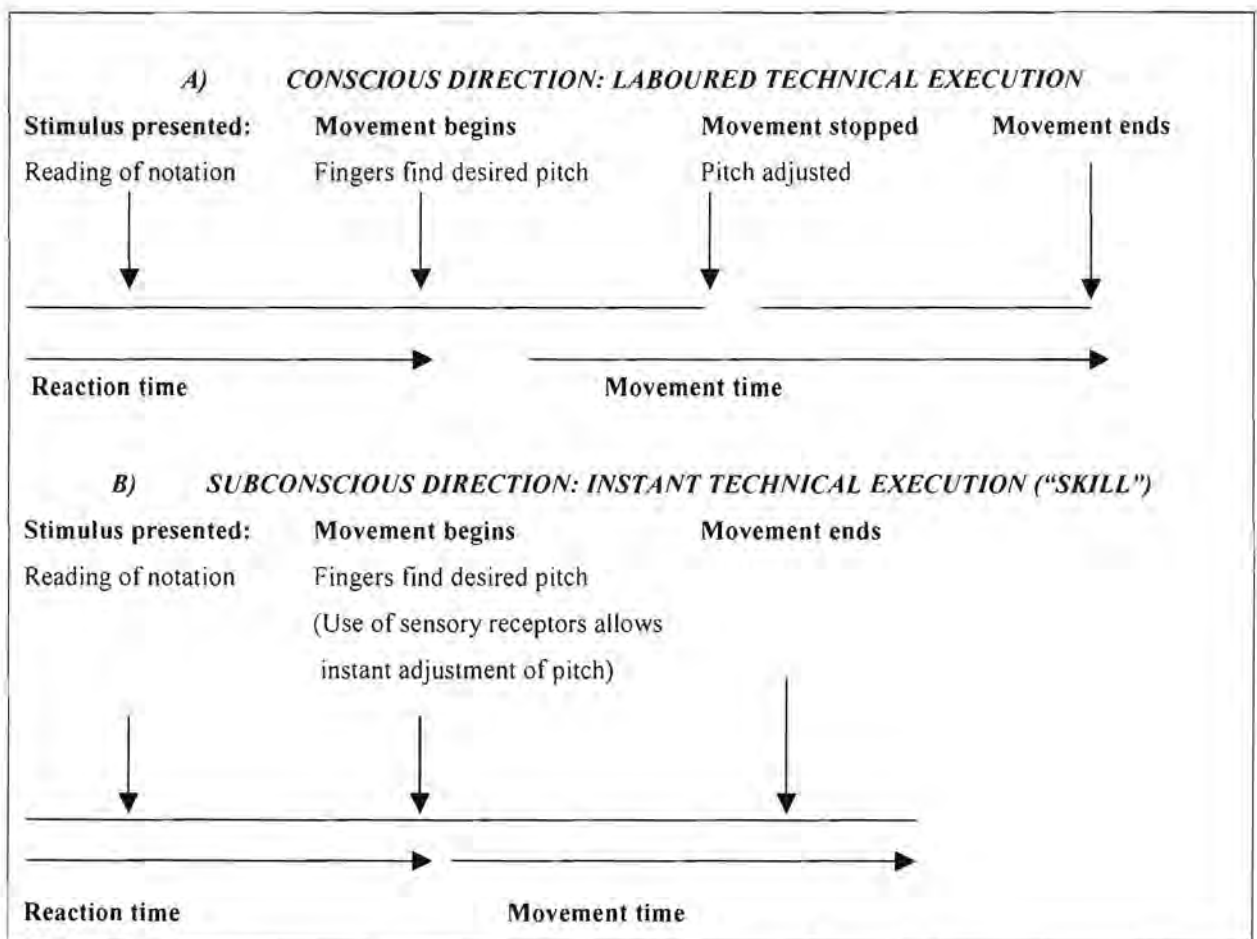


FIG. 4.2. MEASURING SKILL PERFORMANCE: REACTION TIME

The illustration applies the criteria of performance reaction time of intonation in the two different learning environments, namely that of conscious direction and subconscious direction.

In the first example (fig. 4.2.A) pitch is established and corrected via a *conscious process*. The stimulus is presented by means of reading the required notation; the movement begins once the fingers start to find the desired pitch. Once the pitch is sounded, the movement is stopped; the pitch is adjusted accordingly to match the desired pitch and the movement ends. The reaction time is thus interrupted and delayed as the conscious process relies on a stopping of the reaction in order to regulate the pitch.

In the second example (fig. 4.2.B) this reaction time is compared with the *subconscious process* of pitching. The stimulus is presented not only by means of the visual feedback of the required notation, but also by the sensory feedback employed by practise that develops the tactile senses of the hand as discussed before. These sensory feedback loops allow the fingers to “hear” the note and as a result orientates the hand accordingly. The reaction time is therefore much more rapid, as it is not reliant on the conscious processes of regulating and correcting a note that has already sounded.

Galley and Forster conclude by means of the above theory, that subconscious directed movement is far more rapid and therefore skilled. In a musical context (such as pitch adjustment) consciously directed movement requires the pitch first sounding and then being regulated and corrected. This in turn results in a slower response time. In contrast, a reaction time relying on sensory reflex pathways, which have become automated, will be quicker than that of a consciously directed pathway (1987: 103).

**CHAPTER 5**  
**THE ANATOMY OF LEARNING: THE CENTRAL NERVOUS SYSTEM,  
SITE OF SKILLED MOTOR LEARNING**

The preceding discussion illustrated the learning process; the site where this process originates is the central nervous system.

Wilson very aptly sums up the role of the central nervous system in the musician's learning process in the following quote:

“...the process by which a musician achieves a musical goal during performance requires the composition of a neurophysiologic score to guide the physical movements on which the performance is built” (1987: 37).

This means that movement is as a result of muscular contraction, which is regulated by the nervous system and that skilled movement is a process that requires advance planning for optimal results. This whole process is controlled by the brain (Wilson, 1987: 37).

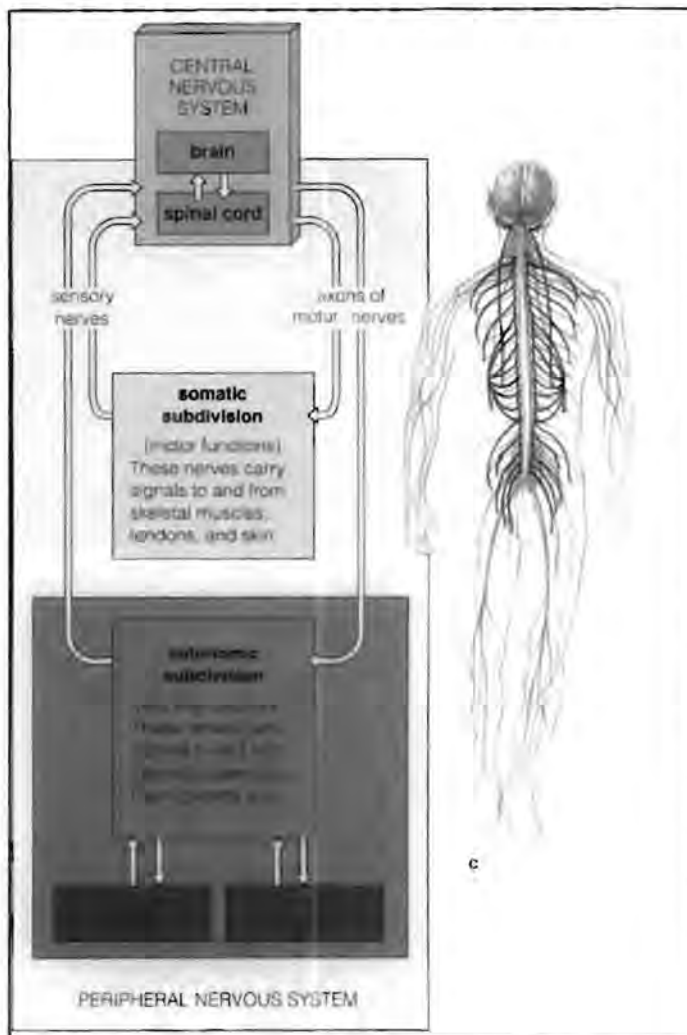
Rolland highlights the importance of an understanding of this basis for learning in his observation that “violin students acquire technical skill through the appropriate use of inborn bodily mechanisms which control voluntary movements...disregard of these natural laws will bring about calamitous results” (2000: 10). Altemuller and Gruhn also note the importance of the physiological process underlying learning in their observation that music performance is a complex sensorimotor behaviour which becomes automated through extensive practise. Neural networks established during this learning process are dependent on teaching strategies (2002: 64).

In conclusion, the physiological process underlying learning is the origin of skilled movement. It is in light of this that the following study is made of the central nervous system - the cradle of all learning.

## 5.1. THE ORGANISATION OF THE CENTRAL NERVOUS SYSTEM

### 5.1.1. THE FUNCTIONAL LEVELS INVOLVED IN SKILL ACQUISITION

The structure of the central nervous system is complex and intricate. Kristeva, Cheyne and Deecke note that the various areas of the cerebral cortex play an important role in the preparation and performance of human voluntary movement (1991:284). The following illustration explains the functions of these various areas of the central nervous system (Starr and Taggart, 1995: 579).



#### Analysis:

Blue: The central nervous system

Green: The somatic system

Red: The autonomic system

FIG. 5.1. : FUNCTIONAL DIVISIONS OF THE HUMAN NERVOUS SYSTEM

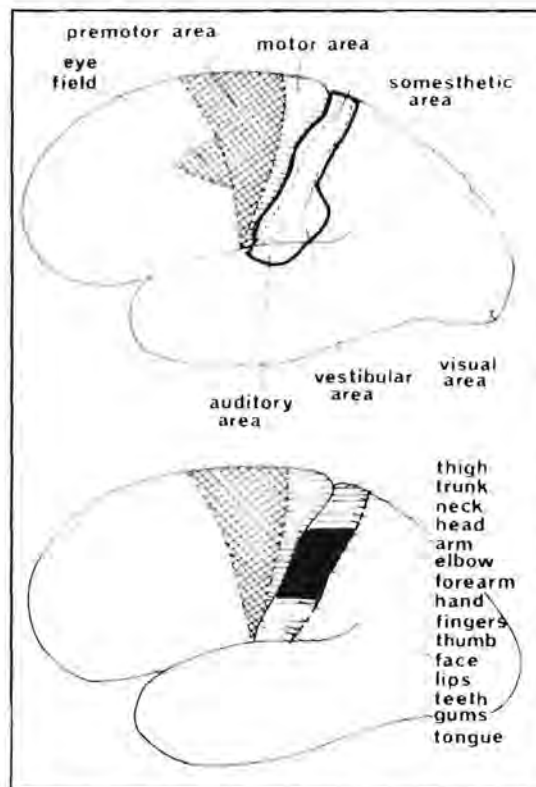
The above illustration reflects the various levels of the nervous system. The blue division depicts the *central nervous system*. This is the centre that senses internal and external conditions, and as a result integrates information and issues response commands to the effectors (muscles and glands). The *peripheral nervous system* describes the communication lines that thread through the body and by means of the sensorimotor neurons supply sensory

information. This division can further be divided into subsections. The first is the *autonomic nerves* (depicted in red), which deal with the body's internal organs and structure, and therefore do not pertain to this study. The second is the *somatic nerves* (depicted in green). The sensory axons of these nerves deliver information from receptors in the skin, muscles and tendons to the central nervous system, whilst motor axons in turn deliver commands from the brain and spinal chord to the skeletal muscles (Starr and Taggart, 1995: 597).

These various levels outline the somatic system as the site of skill acquisition in the left hand of the violinist. The learning of skill is acquired by exploiting sensory information supplied by the sensory receptors of the hand (Luttgens and Hamilton, 1997: 77). A brief discussion will follow into the functioning of the receptors of the peripheral nervous system.

### *Functioning of the Somesthetic Area*

Starr and Taggart very aptly describe the sensory system as the “front doors” to the central nervous system (1995: 594). The following figure shows the sensory representation of the hand in the cortex of the brain (see somasthetic area).



**FIG. 5.2. SOMATIC REPRESENTATION OF THE HAND AND FINGERS**

This sensory system consists of sensory receptors, nerve pathways (leading from receptors to the brain), as well as brain regions where sensory information is processed and translated into

sensation. Somatic sensation of the receptive information is carried to the spinal chord to the somesthetic cortex, notifying the brain and spinal chord of specific changes inside and outside the body. The somesthetic cortex region is laid out like a map corresponding to the body surface; the size of the map region is dependent on the functional importance of different parts. In humans much of the primary somatic sensory cortex responds to receptors located in the fingers, thumb and lips (Starr and Taggart, 1995: 594).

The somesthetic area plays a vital role in the integrating of sensory information. Available evidence suggests that the central nervous system adapts to the challenging demands of the professional musician over prolonged training. When training starts at an early age (before 7 years), there is an actual change in the brain anatomy, as certain structures involved in the learning of the respective skill becomes enlarged. When training starts later, it modifies brain organisation by rewiring neuronal webs and involving adjacent nerve cells to aid in fulfilling the required acts. Such changes result in an enlarged cortical representation of the fingers within the brain (Altemuller and Gruhn, 2002: 72). The value of exploiting such areas in violin playing becomes clear.

Due to the constraints of this study, I will not attempt to delve into great detail as regards the biological processes of sensory impulses of the somesthetic area. Instead, an attempt will be made to give a general overview of the main area of development: the receptors and their role in the construction of skill through the process of feedback.

### 5.1.2. RECEPTORS

Starr and Taggart group sensory receptors into five types. This grouping is based on the type of stimulus energy they detect (1995: 595).

RECEPTORS	TYPES OF ENERGY DETECTED
<b>CHEMORECEPTORS</b>	Chemical energy of specific substances.
<b>MECHANORECEPTORS<sup>1</sup></b>	Forms of mechanical energy (changes in pressure, posture and acceleration).
<b>PHOTORECEPTORS</b>	Light.
<b>THERMORECEPTORS</b>	Infrared energy (heat).
<b>NOCIRECEPTORS</b>	Tissue damage (pain).

The term “sensory nerves” refers to those nerve endings of the peripheral nervous system which enable us to see, hear, smell, taste and respond to touch (Starr and Taggart, 1995: 579). The primary sensory areas of interest for the aspirant violinist attempting to learn new motor skills are the tactile, auditory and visual senses. The information from these senses is provided by neurons in the receptors, which convey sensory information to the brain. This alters the muscles as to the required movement which should be executed in order to master the specific skill being learnt or practised (Starr and Taggart, 1995: 596). Nichols notes that central nervous system determines skeletal muscle activity, and that a major source of this activation is sensory feedback from the receptors (2002: 544).

Sensory information in the left hand is provided by the tactile sensory nerve endings in the pulp of the fingers (referred to as mechanoreceptors) which receive the information from the external environment. This information is then sent to the brain where the information is processed, and feedback is then given to the motor neurons to activate the muscles required to execute a specific skill (Galley and Forster, 1987: 220).

De Wet explains that by exploiting the sensory receptors in the finger pulps (fleshy part of the nail joint), the violinist heightens the hand’s sensory function. This is the basis of a skilled and rapid left-hand response, which plays an extremely important role in the building of a versatile and secure technique. The sensory reflex is far more reliable than the delayed

<sup>1</sup> It is important to note here that the fingertips have the greatest sensitivity to this form of stimulation.

reaction of the ear, as pitch adjustments that rely on auditory perception can only be adjusted consciously once the note has already been sounded (1998-2004).<sup>1</sup>

Altemuller and Gruhn support this principle in their description of sensory adaptation by the receptors of the violinist. They state that it is not only motor areas that are subject to anatomical adaptation, but by monitoring nerve cells involved in the processing of sensory stimulation in individual fingers, professional violinists have been shown to possess enlarged sensory areas that correspond from the index finger through to the small finger of the left hand (2002: 69).

### 5.1.3. FEEDBACK LOOPS

Theories about motor skill performance and learning can help us establish guidelines for instruction, which in turn allows the teacher to develop effective strategies that enhance motor skill learning (Magill, 1998: 38). Thus far a summary has been given of the characteristics and physiological integration of learning. This will now be followed up with a discussion on the integration of sensory perception and the role of the violin teacher in refining this process.

Magill concludes that the process of co-ordinated fine motor skills exists within a feedback loop system. Oswald, Lewis and Maler very aptly describe feedback pathways as the sensory searchlight that enhances the detection of signals (2002: 2462). The feedback loop refers to the way in which the central and peripheral nervous system initiates and controls action (Magill, 1998: 38). In fact the underlying basis of motor control activities consists of interplay between central planning and the processing of feedback (Proteau, Marteniuk and Levesque, 1992: 557). The following illustration (Fig. 5.3. Magill, 1998: 39) serves to explain this system.

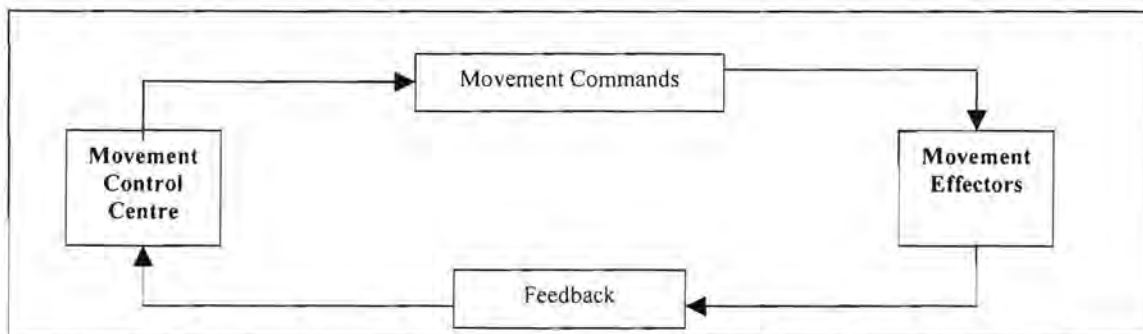


FIG. 5.3. FEEDBACK LOOP MODEL OF CONTROL

<sup>1</sup> See Fig. 4.2.

Magill describes the control centre depicted above as the site that generates and issues movement commands to the effectors, which are the muscles and joints involved in producing the desired movement (1998: 37).<sup>1</sup>

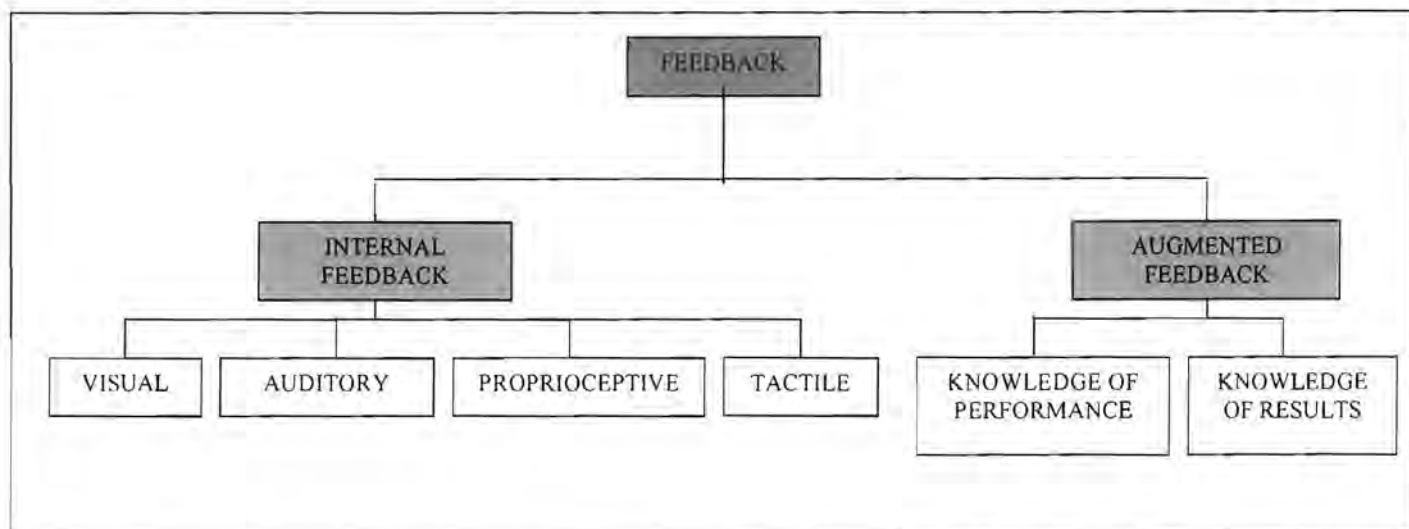
An important aspect of the model of control is that it involves feedback. In the movement of violinists this feedback refers to afferent information passed from the sensory receptors (as discussed) to the control centre. This feedback is important in integrating physiological acts into the students' cognitive structures of understanding. The purpose of this feedback is to update the control centre about the correctness of the movement while it is in progress. It must also be noted here that in complex human movement 'effectors' are not the only source of information, but instead information is also drawn from the visual, auditory, tactile and proprioceptive receptors referred to earlier (Magill, 1998: 38). Proteau, Marteniuk and Levesque summarise the role of feedback in their proposal that the underlying basis of motor control is the interplay between central planning and processing of feedback (1992: 558).

The learning of complex skilled motor movements, such as playing the violin, does not rely solely on the feedback loops referred to earlier, but is also reliant on the process of augmented feedback (Magill, 1998: 185). This form of feedback refers to the external feedback given by the instructor, or in this case the violin teacher. This further highlights the importance of the teacher in the learning process.

These inter-linking processes of learning are further referred to as 'external' and internal' by nature. In other words, internal feedback refers to the sensory feedback that occurs as part of the skill performance situation, while augmented feedback refers to the feedback that is sourced from the external environment (teacher) and adds to or enhances the intrinsic feedback that is occurring. Once again this process is best reflected by means of the following figure by Magill (1998: 186).

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<sup>1</sup> This highlights the importance of the optimum functioning posture of these various muscles as discussed in chapter 2.



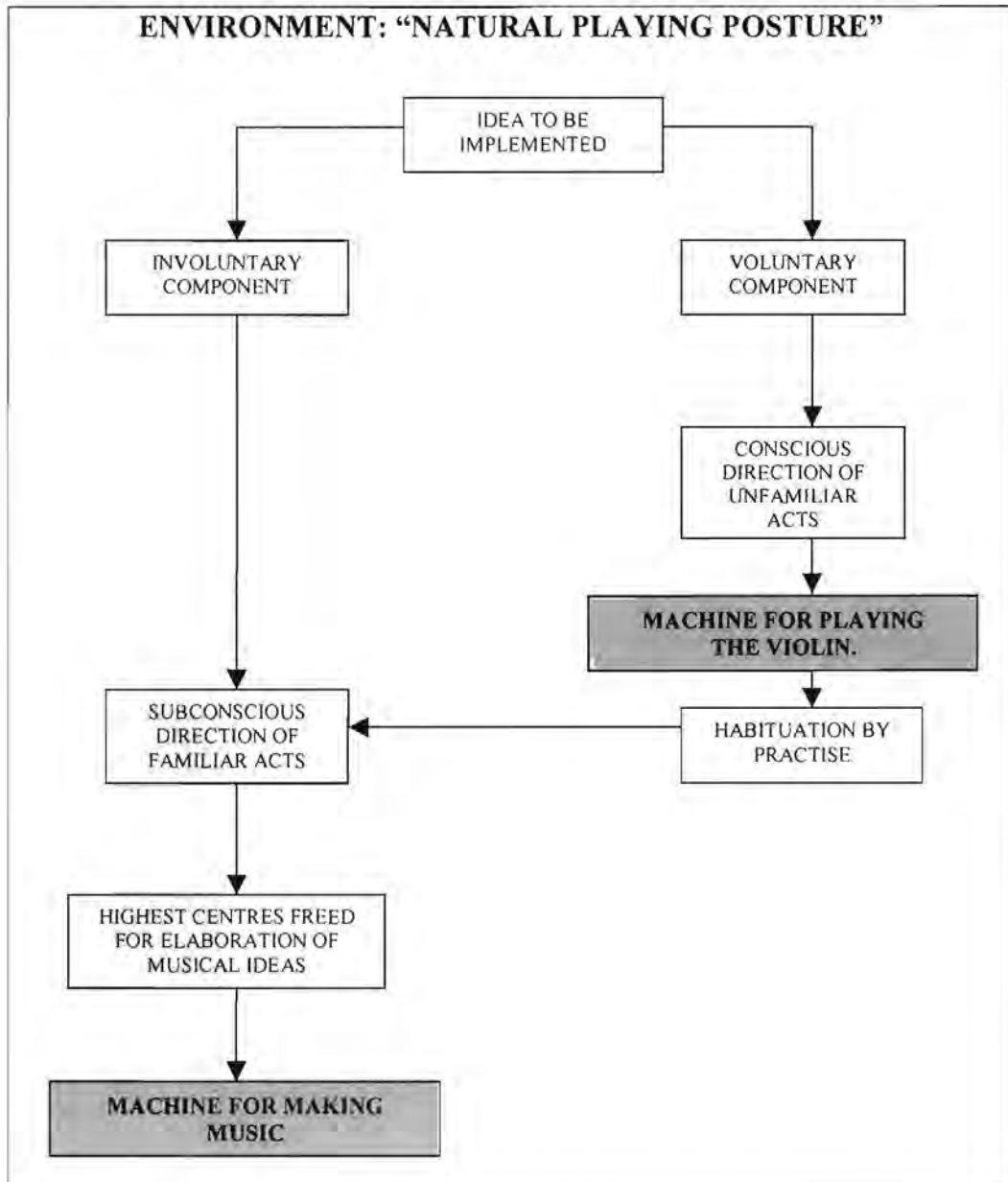
**FIG. 5.4. DIFFERENT TYPES OF FEEDBACK IN THE FEEDBACK FAMILY THAT ARE RELATED TO LEARNING AND PERFORMING MOTOR SKILLS**

The diagrams and discussions above cast light on the importance and the quality of information continuously being integrated by the student, be they internal, by means of sensory information, or external, by means of the teacher. The impact of an ill-informed teacher on the quality of learning becomes apparent.

## **5.2. THE ROLE OF SENSORIMOTOR PROCESSES IN THE TECHNICAL SKILL DEVELOPMENT OF VIOLINISTS**

Skilled acts, such as the development of left-hand technical acts in violinists are a result of automated action built on the integration of sensory information. The significance of this theory lies in the end goal, to which all-aspirant violinists and teachers strive - the art of music making, unhindered by misdirected actions.

Figure 5.5. summarises the synthesis of the various physiological processes that leads to this final phase of music making. It is an adaptation of a figure by Rolland, and represents the two phases of learning, namely the conscious and subconscious phase (2000: 21). These processes exist within the environment of a natural posture, which does not hinder learning, and in turn allows for the integration of feedback on an internal and external level. As depicted, the result is freedom of movement and technical skill, which in turn allows for music making.



**FIG. 5.5. TWO PHASES OF THE PHYSICAL ACT OF VIOLIN PLAYING**

Rolland notes that these sensorimotor processes play an important role in the acquisition of skilled acts. He states that positional adjustments are important for co-ordinating fine motor skills. These skills are guided by sensory feedback from receptors in the muscles themselves. They in turn evoke responses affecting the body as a whole, such as posture, securing of the violin, as well as freedom and positioning of the upper extremities. A continuously adapting postural support provides a substrate upon which the execution of skilled movement depends (2000: 21).

The portrayal of the 'machine-for-playing-the-violin' and the 'machine-for-making-music' warrants consideration because contemporary pedagogy trends recognise that the machinery

of the living body, in this case the central nervous system, deals coherently with autonomous operations, thus leaving the mind free to contemplate activities largely overlooked in traditional orthodox teaching (Rolland, 2000: 21).

**CHAPTER 6**  
**CONCLUSION: THE ROLE OF PHYSIOLOGICAL PROCESSES IN LEFT-HAND**  
**TECHNIQUE**

The approach to string teaching has often been extremely inflexible, whereby aspirant violinists were expected to go through the selfsame technical ritual which was regarded as the only way to achieve technical facility and freedom in playing. As a result of research done into sport medicine, as well as the increased awareness of the reciprocal interaction, which takes place between human physiology and the nervous system, pedagogues and violinists are now in a far better position to understand the physiological needs of the violinist. This change in contemporary string pedagogy realises the sensorimotor needs of each pupil.

In this new-found didactic approach, the struggle to understand why certain rules should be followed is set aside and an attempt is made to explain, from a physiological stance, the preferred methods of teaching the physical skills associated with music making. Pedagogues should look beneath the surface of an attractive and practical instruction method, and rather draw upon the beauty of the physiological mechanisms that seem to be responsible for its success.

Contemporary string pedagogues are now in the fortunate position to better understand how the aspirant violinist should be guided to find the best sensorimotor criteria required to execute a specific technical skill. This results in a subconscious act, which leaves the violinist free to concentrate on musical concerns.

The starting point should be the development of a good and secure posture which is as 'natural' as possible. This will encourage the pupil to play in harmony with the body rather than against it. A good posture will not cause any undue muscular tension, and will in turn promote a secure and good technique. The technical development of a skilled left hand relies heavily on a postural awareness that takes due cognisance of all the muscles and movements required in the learning of even the most simple of skilled actions.

The dissertation is built on the premise of an interactive model, which takes cognisance of reciprocal interaction between the sensorimotor functions as regulated by the brain. Here, the tactile information that the sensory receptors in the finger pulps supply, conveys information

to the brain, where the information is integrated into cognitive structures and subsequent feedback is given.

In order for violinists to acquire technical freedom, they should attain a high level of skill by development of the most reliable and complex mechanisms of the body “machine”, namely that of the sensorimotor systems. In this way technique becomes an automated reflex, unhindered by environmental disturbances.

This study hopes to cast light on the importance of the underlying physiological processes of learning which lead to skilled left-hand technique. The sensory aspects are indeed one of many areas of development in the acquisition of skill. This study does not wish to conclude that it is indeed the only area required for the furthering of skill acquisition. However the study of this nature aims to highlight the need for further research and a greater understanding of the biology of learning and development of skilled acts in order to attain musical goals.

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