CHAPTER 1
INTRODUCTION

1.1 A brief survey of thought concerning piano technique since 1750

An understanding of the current thoughts on piano technique prevalent among pianists and teachers requires some insight into the way piano technique has developed over the better part of three centuries. Historical surveys of the evolution of piano technique, varying in scope and completeness are fairly common, having been performed in the second half of the 20th century by *inter alia* Boardman (1954), Kloppenburg (1960), Kochevitsky (1967), Künkel (1965), and Jaeken (1990). In order to heed Stangeland's (1980a:37) rather astute notion that "[i]t is the thinking musician, the thinking pianist in particular, who will not discount entirely the contribution to technical thought and practice of any one school of thought", some of the most important trends will be pointed out here briefly.

According to Stangeland (1980a:32), one of the first schools of technique emanated from the characteristics of the technique used to play the earlier keyboard instruments. Since the fingers were sufficient means to master these earlier instruments, this school is named the *finger school*. Major treatises that signify the beginning and the ending of the period in which this mode of thought predominated, are the *Essay on the True Art of Playing Keyboard Instruments* of 1753 by C.P.E. Bach, and the *Complete and Practical Pianoforte School* of 1837 by Czerny[1]. According to Kochevitsky (1967:3), exponents of the finger school held that only the fingers should be used, keeping the upper parts of the arm stationary. The development of technical facility was regarded as purely a mechanical procedure, requiring many hours of incessant, repetitious daily practice. The teacher was regarded as the absolute and final authority on matters such as the solving of technical problems and scheduling of practice. Stangeland (1980a:32), however, points out that the thoughts on technique of C.P.E. Bach, who employed a close finger technique, apparently extended beyond the stereotyped use of the fingers as suggested by Kochevitsky:

> A close finger technique usually suggests participation of other parts of the playing mechanism in depressing keys ... certainly Bach's reference to the hand (possibly even the arm) stroke is

[1]Boardman (1954) considers this school to have been the major direction of thought for the first century in the history of piano technique, i.e. from 1750 to 1850.

proof that he advocated more than finger action.

So did the views of many others, if their insistence on a singing tone for the execution of long musical phrases (Stangeland 1980a:33) is taken as the criterion.

Stangeland (1980a:33) notes that the technical principles of the finger school have been subjected to misinterpretation in that later authors have regarded the role of the fingers as greatly over-emphasized by the finger school; "[g]ranted, ... [the fingers] are on the periphery of the playing apparatus, but without them the piano simply could not be played". Even though power can be initiated somewhere else in the body, the role played by the fingers is always an integral part of piano playing, and as such should never be neglected.

Referring to the influence of the views of finger school exponents on later generations of pianists, Stangeland (1980a:32) makes an important comment on the division into time periods of the history of the development of piano technique:

> [Division into time periods] is not to suggest that there were no proponents of the school of finger technique after that time nor that certain features of this school of thought are not integrated into living techniques of some of the great performers of today. Nor are we able to assume that during the epoch of finger technicians there were not those who anticipated other schools of technical thought, consciously or unconsciously.

The second important school of piano technique is the school of the arm and its weight, or the *relaxation school*. Precursors of this school included Kalkbrenner, Kohler, and Kullak, but the most important figure among them was probably Ludwig Deppe, regarded by Stangeland (1980a:34) as "[p]erhaps the most systematic piano theorist of the nineteenth century". Stangeland (1980a:36) summarizes the essentials of Deppe's rather visionary approach, which anticipated many later writings on technique, as follows:

> ... his ideas encompassed ... the importance of critical listening to sounds produced and their relationships, the coordination not only of the physical mechanism itself but the coordination of mind and playing apparatus, stressing the necessity of developing control from the brain to the fingertips. His theory of movement was highlighted by continuously curved movements rather than angular straight-line movements and he was opposed to striking the keys with equal hitting power as had been advocated by some representatives of the finger-technique school.

Kochevitsky (1967:9) however notes that Deppe's ideas were subjected to misrepresentation by some of his followers. Also, his lack of lucidness in explaining his beliefs lead to misunderstanding; the most notorious example probably being the matter of the free fall of the arm, which for rather obvious reasons should be regarded in a metaphorical sense rather than taken literally (Kochevitsky 1967:8).

According to Stangeland (1980a:36), Matthay and Breithaupt were the leading exponents of the school of the arm and its weight. Their insistence on their students listening to themselves and

approaching technical problems intellectually had a positive influence on later generations (Stangeland 1980a:37). Matthay (1947:12) advocated the bond between music and technique and "... the need for a particular mental-muscular association and cooperation for every musical effect" (Stangeland 1980a:36). His concept of relaxation did not disregard the role of the fingers, as can be deduced from his statement that (Matthay 1924:77) "[w]e must acquire the power to *use* our fingers and hands quite independently of any downward-acting arm-force, and even independently of arm-weight". According to Stangeland (1980a:37), Breithaupt made a considerable contribution by pointing out fallacies of the finger school such as fixed hand positions, and by stressing that the arm's movement versatility, i.e. for lateral, vertical, and rotational motions, could lead to more physical ease in piano playing. Stangeland singles out, as probably Breithaupt's most advanced idea, his notion that

> ... all fingerings ought to result automatically from natural movements. Such a theory depends, of course, upon a discernment of what is natural or unnatural for a given individual and is therefore open to question.

Out of the relaxation school originated a direction of thought in which the emphasis was placed on the coordination of all the body parts required for technical execution (Stangeland 1980a:37). Important exponents of this school included Gát, Ortmann, Fielden, and others, whose writings intended "... to stimulate the aspiring pianist to search out and study for himself where truth resides". Although this school is usually associated with 20th century technical thought, some earlier teachers and pianists were probably aware of its advantages as well. According to Stangeland (1980a:37), the common denominator between these authors was a belief in the "... importance and indispensability of the coordination of physical parts themselves, as well as the coordination of the physical playing mechanism with the ear, the mind, and the nervous system". A predecessor of this school who made some noteworthy contributions, Oscar Raif, showed through experiment that the demands made on an individual finger in piano playing with respect to agility, usually is much less than its natural capability (Kochevitsky 1967:12).

Coexisting with the coordination-movement school was the psycho-technical school, who stressed "... psychological and nerve factors in the development of technique" (Stangeland 1980a:37). An important precursor was Steinhausen, who held that practising is "first and foremost ... a psychic process" because all muscular activity is initiated and controlled by the central nervous system (Kochevitsky 1967:13). Prominent exponents of this school, which is essentially concerned with "... how the conscious mind can influence the subconscious in the realization of the musical substance of the piece being performed" (Stangeland 1980a:37), included Busoni, Bardas, Egon Petri, and pianists like Schnabel, Godowsky, and Gieseking. Extreme manifestations of this school of thought could however induce one to "... wonder over the necessity of physical practice at all" (Stangeland 1980a:37). According to Kochevitsky (1967:16), the psycho-technical approach generally held that technical problems should not be divorced from their musical purpose and that different technical

problems should be attempted from different points of view. Muscular sensation is more important than observation of movement form. All parts of the pianist's bodily apparatus should be used freely and completely in order to establish the desired musical purpose in a convenient way (Kochevitsky 1967:16-17). Also, most hands can be considered sufficient equipment for establishing an advanced technique "... because of the brain behind the hands" (Kochevitsky 1967:17). All facilities should be employed in an interacting manner for achieving meaningful movements: "... the inner musical imagination, the innervation of movement, muscular sensations, and careful and critical listening to the results" (Kochevitsky 1967:16).

1.2 Statement of problem and purpose of study

The purpose of the present study is to investigate and contrast the potential value of two theoretical viewpoints from motor behaviour science in psychology for addressing the motor[2], i.e. technical, problems of piano playing. The term *technical* is used here in its broadest sense to include any problem involving muscular movement in piano playing.

Many reasons can be brought to the fore for reverting to psychology in order to address the problems of piano playing. Some of the most important of these reasons will now be stated below.

The vast majority of books that have been written on piano technique employs a physiological approach to the solving of technical problems; according to Lee (1977:3), "... most books on technical theories begin and end on physiological discussions of piano playing mechanics". Kochevitsky (1967:18) endorses this observation by stating that

> [f]or two hundred years pedagogical thought looked to the pianist's playing apparatus - to muscle work, to positions and movements of arms, hands and fingers - for the solution of all technical problems.

The problem with such an approach is that instructions from teachers to students - or, for that matter, instructions found in the plethora of books written by pedagogues and performing artists from their own experience - "[n]o matter how well-intentioned", have the potential to mislead the student (Stangeland 1982:38). The most obvious reason for this is simply that it is extremely difficult to convey verbally how complex, highly refined movement patterns have to be executed by the (equally complex) muscular playing apparatus of another player. As Ortmann explained in a personal correspondence to Gerig (1974:412) about his investigation into the "whys and wherefores of individual technical variations",

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[2]The term *motor* implies "causing or imparting motion" or "... involving muscular movement" (The Penguin English dictionary 1985:537).

> [t]he explanations given me were so often the subjective expression of the player himself that the underlying physiological facts were unintelligible, nor was there agreement among the pupils even of any one teacher.

As suggested above, the rather unpredictable factor of individual differences in physical apparatus and ability causes the generality of the physiological approaches to be questioned. That individual differences in performing even relatively simple tasks should not be underestimated, was illustrated using scientifically-based means by McArthur (1988:1692-A): in an experiment, involving a computer analysis of the movements employed by two highly skilled pianists playing an elementary piece, she found little similarity between the movement patterns of the two subjects. Thus, Gát's (1958:5) observation that the main fault of the majority of books on piano playing, is that they rely too much on the individual experiences of the authors, does not come entirely unexpectedly.

It is of considerable interest to note that certain physiological strategies for enhancing piano technique seem to persist in being widely employed in spite of clear indications in the literature of their detrimental effects. One such practising strategy in particular - which is aimed at obtaining the intertwined properties commonly referred to as finger strength and finger individuality - can be traced back to at least as early a piano teacher as Clementi; it involves (Kochevitsky 1967:3) each finger striking its key repeatedly while the other four fingers hold down their keys in the five-finger position. Various authors have pointed out that exercises based on these principles can be highly detrimental; Neuhaus (1973:85), for instance, inquires

> ... how many hundreds and thousands of pitiful beginners ... when brought by their teachers into contact with the keyboard for the first time tried to turn their living hand with its nerves, muscles, flexible joints and pulsating blood, into a piece of wood with curved hooks ...

Sandor (1981:158-159), in agreement with Neuhaus, identifies as reason for the harmful effects of the above-mentioned exercises, the fact that finger and arm muscles are forced to function in a manner other than antagonistically, thus giving rise to severe muscle tension. Some authors even go as far as to question the principle behind the exercise; Prostakoff and Rosoff (1969:7) observe that

> ... let the student be taught that he needs "strong and independent fingers, and a steel-like wrist" and from then on, all too often, his musical goose is cooked!

It is therefore rather disconcerting, giving the convincing nature of the arguments above, to find in the recent literature on piano methodology that similar, if not identical, "finger independence studies" are prescribed or endorsed by eminent authors, for example Bastien (1977:244).

The above arguments bring another problem to the fore, namely the vastness of a literature in which a large variety of viewpoints, often on the same problems, is scattered throughout many volumes. Furthermore,

> ... points of view of individual authors are sometimes narrowly based, without positive consideration of the value of past or contemporary technical approaches. Therefore, much of what is written is not helpful unless it is read in conjunction with the writings of others ...

(Stangeland 1980b:40)

1.3 Perspectives from which the present investigation is conducted

While it is noted that the practical wisdom of pianists and teachers should by no means altogether be disregarded or discarded, another approach to the complex motor problems of piano technique clearly needs to be adopted. Taubman (Schneider 1983:21) is rather frank on this matter:

> [w]hy should music be left in the Dark Ages? Mathematics and science have moved into the 20th Century, while 300 years of piano pedagogy have been handed down without research or evaluation. We can't afford the luxury of every teacher having his own untested theories of technique. The whole tradition must be weighed, codified, and tested against our contemporary knowledge of the basic principles governing body movement and the mechanical laws governing the piano.

Other authors clearly feel the same way; Kochevitsky[3] (1967:18), for example, is of the opinion that "... the main attention of thoughtful pianists and piano teachers" should be focused on the activities of the central nervous system. Bridges (1985:iii) sets down guidelines for developing "... a cognitively-oriented concept of piano technique" by integrating means obtained from the fields of psycho-physiology, motor behaviour science and psychology of consciousness into a framework of performance goals. The advantages for the pianist offered by knowledge of these fields of psychology can be described as follows (Bridges 1985:iii):

> *Psycho-physiology* offers the pianist evidence for relying as much as possible on reflex activity in developing technical skill. *Motor behavior science* provides a model with which a pianist can analyze his own internal processes during practise and performance. *Psychologies of consciousness* provide insights into how the mind can help or hinder those internal processes. [Italics added.]

According to Bridges (1985:18), concepts from psychology such as those mentioned above are by no means alien to the field of piano technique, because all writings on piano technique have some sort of psychological basis, whether the writer consciously intended this or not: "He [the writer] may assume too much psychologically or assume wrongly, but nonetheless ... every piano method is basically a conceptualization of motor behavior". The fact that such a wide variety of piano methods have seen the light in this century can in fact be attributed, at least in part, to a poor understanding of the psychological principles underlying motor control and learning (Bridges 1985:19).

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[3]Bridges (1985:48) points out that Kochevitsky's understanding of motor skill development is based largely on the Pavlovian school of reflexology, "... which has fallen out of use in present day psychophysiology" - thus rendering his viewpoint of this problem, proposed in 1967, outdated. By directing attention to the mind in the solving of technical problems, however, Kochevitsky has nevertheless made a lasting contribution to this field.

Bridges (1985:2) notes that motor behaviour science has never been seriously applied to the study of piano technique; pianists have rather used formal psychology in order to address the problem of performance anxiety and to aid the learning and memorizing of music.

According to Sidnell (1986:7), music educators have for quite some time been aware of the need for and importance of research into motor learning as pertaining to music education. It is not difficult to realize that the movements required for musical instrument performance are probably among the most demanding and complicated that can be expected of the human body -

> [e]ven without the music reading process present, music performances by ear, memory, or improvisation require long chains of precise motor activity, always with constant, sophisticated auditory monitoring.

Sidnell emphasizes that the interest of the music education community in motor behaviour research has unfortunately not transcended the level of mere lip service;

> [w]hen one surveys the research literature in music education, the paucity of systematic investigation by music educators of motor learning problems is alarmingly evident. For all our verbal dedication to the importance of motor learning to rhythmic development, for example, ... [little] bibliography of significance [can be provided].

Two reasons are identified by Bridges (1985:5-6) for the lack of research effort into the motor skills of piano playing in particular. The first is that it has long been taken for granted in Western culture that humans have total control over voluntary motor responses, implying that the most effective way of developing skills involving coordination is through conscious manipulation of the limbs. The second reason is the negation of the study of mental processes in the behavioural psychology approach to movement science that was prevalent for the largest part of this century. As Bridges puts it,

> [b]ecause conscious mental activity obviously plays such an enormous role in the psychological aspects of piano technique, it is easy to see how the behavioral approach would give disappointing results to any pianist looking for a scientific answer to his problems.

As mentioned earlier, this thesis will focus on *motor behaviour science*, which is one of the fields of psychology suggested by Bridges for developing a cognitively-orientated concept of piano technique. In particular, the disciplines of *motor control* and *motor learning* will be addressed, with special reference to their manifestations in piano technique. These disciplines will be investigated from two contrasting perspectives, namely the more "traditional" *motor systems theory*, and the newer *action systems theory*.

Although Adams (1987:41) is of the opinion that motor control "... is a child of physiology and of information processing in psychology, neither of which have had much interest in learning", Schmidt (1988b:4) indicates that neither motor control nor motor learning should be studied in isolation: "I see no good justification ... for separating the study of motor learning from the study

of movement or of motor control in general, as this artificial separation inhibits the understanding of both issues". In the present study, therefore, although motor control and learning will be discussed in separate chapters, it is inevitable that some of the subject material will overlap in order to ensure a complete representation of the matter at hand.

The *motor systems approach* to motor control and learning is characterized by the use of information-processing models adopted from communications engineering and the notion that all movement is built up out of elementary neuro-behavioural units (Reed 1988:46). It holds that all action is centrally controlled, for example by means of a motor program. The motor approach can be described as the "traditional" approach, and can also be referred to as the man/machine approach, due to the fact that most of its concepts are gleaned from control and computer engineering.

The goal-orientated *action systems approach*, on the other hand, is defined by Reed (1988:46) as

> that [functionally based] area of motor skill research that emphasizes task orientation and offers a taxonomy of acts based on goals ... but ... adds the assertion that evolution has resulted in a number of autonomous action systems which work in their own way to achieve specific functions.

Any action is made up of components which have a specific function and would themselves count as actions (Reed 1988:49). The action theorists reject the motor approach and the existence of motor programs; Meijer and Roth (1988:xi) thus aptly describe the significance of the advent of the action approach as follows: "[o]nce in a while, the psychological community is disturbed by the emergence of a group of researchers who proclaim that Psychology has been looking in the wrong direction altogether ...".

Throughout the thesis the approach to these topics will be critical, i.e. criticism of the motor systems approach from the action systems viewpoint will be presented, and vice versa.

1.4 Research strategy and delimitation of subject material

The nature of this thesis will be exploratory, consisting of a study of relevant literature on piano technique and psychology. As the main point of departure of this study is that of a musician, conclusions on the significance, and criticisms on the work done by psychologists in the motor behaviour field, will be restricted to the opinions published in this regard by their peers.

Limiting the present investigation to motor control and learning in motor behaviour science, which does not have a particular interest in the cognitive component *per se* of human behaviour, can be

justified by practical considerations as follows: in the natural sciences like physics and biology, general theories exist which describe and explain a wide range of phenomena. Regarding piano technique, no such theory exists. A study of certain fields within psychology could provide a starting point for working towards a "method" of piano technique with at least some degree of generality. But "[e]ven within psychology, so many findings are relevant that coherence requires selectivity" (MacKay 1987:xiii). Therefore, to retain coherence within the scope of a masters thesis, the topics addressed are restricted along the lines mentioned above.

It should be emphasized that the purpose of the present study is not to prove valid or invalid any particular method from the piano methodology literature. Therefore, physiological remedies for technical problems, which abound in the literature on piano technique, are not discussed *per se*, but only when an underlying principle relevant to the motor and/or action approach can be identified from the context in which the specific author discusses that particular physiological strategy. In many cases, it will be possible to cite a great number of examples and/or opinions from the field of piano playing to illustrate a particular concept. Of these, only sufficient representative specimens to motivate the relevant issue will be retained. The same treatment holds for matters of musical interpretation.

Noting that scientifically proven data from psychology directly applicable to piano playing appears to be extremely scant, it seems that research on piano technique from a psychological perspective would to a considerable extent be restricted to an approach of, as Bruno (1985:1669-B) phrases it, "logically extrapolat[ing]" from the information available on motor control and learning, "... with concepts gleaned and correlated from ... psychology and other sciences". It is, however, imperative that great care should be taken in matters where such "logical extrapolation" seems to be required. This statement is perhaps best motivated by quoting Adams's (1987:52) view on adaptive training, a learning method which applies the techniques of individualized programmed instruction by computer directly to motor skill learning:

> Assume, for example, that a trainee is learning algebra with programmed instruction. Problems are regularly missed because he or she cannot multiply fractions. The system, detecting this shortcoming, can branch the student to exercises in fractions until a performance criterion is met, at which time the student is returned to algebra problems. *Believing that these operations should work for skills learning is thinking by analogy, which is hazardous in science.* [Italics added]

Similarly, what holds for verbal memory, for instance, cannot matter-of-factly be extrapolated to account for motor memory as well. And the various methods of piano pedagogues introduced over a period of decades, or even centuries, cannot simply be forced into some preconceived psychological mould, of which the underlying models and assumptions were conceived formally only after the

demise of some of these pedagogues[4].

Adams's point of view stated above links closely to what Schmidt (1988b:50) terms *validity* of the measurement of motor skills, a concept which can be described as "... the extent to which the test measures what the researcher intends it to measure". This implies that conclusions drawn from an experiment measuring for instance typing speed, cannot be simply assumed to have direct bearing on piano playing as well, because the test was designed in the first instance to measure a certain variable connected with typing - not piano playing.

The present study will be carried out mainly at what can be termed the *behavioural level of analysis*; thus

> ... the primary focus is on movement behaviors that can be observed directly and on the many factors that affect the quality of these performances and the ease with which they can be learned. (Schmidt 1988b:ix)

This approach is completely appropriate for piano playing; although movements refined through practice sometimes become hardly visible, visual recordings can be used to make these movements more observable. In the traditions of cognitive psychology, however, internalized models, which describe for instance how information from the environment leads to motor responses, will be included for treatment as well, especially in the discussions involving the motor systems approach. Explorations into the specialized area of neurophysiology will generally be refrained from, except in one or two instances where circumstances warrant additional elucidation of this nature.

Finally, it is necessary to make some specific statements with respect to certain subjects the present study is *not* concerned with.

Firstly, the present study is not concerned with the development of skill in children in particular; thus the general approach should not be thought of as developmental[5]. Rather, an attempt is made to bring information to light which could be of use to any pianist who is ready to implement such information in his practising strategy.

In the second instance the study does not deal with sight-reading, aspects of which have been treated in depth by *inter alia* Fourie (1986, 1990). As far as piano technique is concerned, the learner is generally assumed to know by heart the actual sequence of notes that requires physical

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[4]It is not certain whether Bridges (1985) has refrained from this practice. In the second chapter of his thesis, entitled "Implicit psychologies of piano technique", he identifies information processing models underlying the "methods" of various pedagogues, even though such models are not even hinted at by most of these pedagogues.

[5]A developmental approach in the context of the present study would imply an emphasis on the various stages of motor skill development in *children* with respect to piano playing.

execution; perception of the note picture in interaction with the actual execution is therefore excluded from the present thesis. Pianists are in any event almost universally required to perform from memory; it is also highly unlikely that complicated technical problems can be attempted successfully while the learner is still confined to the printed score[6].

Thirdly, although performance anxiety can seriously disrupt performance, that subject, as well as other affective factors that can influence piano playing, is not included for detailed treatment here, as performance anxiety is a field of study in its own right. Furthermore, technical problems can hardly be considered to be the domain of performers with stage fright only. Bridges (1985:5) thus aptly points out that "[t]here can be uncoordinated piano playing in happy, contented pianists just as well as nervous, diffident ones".

It should also be pointed out that, except in cases where particularly useful insights stand to be gained, results on motor control and learning pertaining to orchestral and band instruments will not be dealt with, because of the rather obvious and huge differences among the motor tasks involved. This view is supported by Handel's (1986:19) statement on the likelihood of obtaining general answers to questions on motor learning in music education: "I would suggest that general answers are unlikely because the requisite motor learning skills vary across the different kinds of music performances".

Finally, it should be pointed out that, in order to keep the number of topics discussed within manageable proportions, the subjects of *individual differences*, i.e. the "stable differences among individuals on some variable or task" (Schmidt 1988b:342) and *individual abilities* are generally not included in the present discussions.

In order to set the scene for a motor behaviour science approach to the problems of piano technique, some general issues, which are currently of interest in music education for motor learning in musical instrument performance, will be discussed in the following section.

1.5 Sidnell's issues on motor learning in music

In 1978 a paper was presented by Robert Sidnell (1986) in which some important questions with respect to motor learning in skilled musical performance were identified. Through an examination

[6]Gieseking and Leimer (1972) advocate that serious (technical) work on a piece can begin only after it has been memorized; they recommend visualization in particular to achieve this independence from the printed score.

of these questions, an indication can be obtained of the angle motor behaviour science has to be approached from, in order to be of use in addressing the technical problems associated with the playing of musical instruments. Although Sidnell's approach to these matters shows a developmental interest, the issues he raises are nevertheless of considerable importance for the present study. It is thus appropriate to devote some special attention to some of these questions which, according to Hedden (1987:28), remain mostly unanswered:

> In 1978, Sidnell and the present author [Hedden] found it astounding that the profession had so little confirmed knowledge about an area that is such a basic part of all music education programs; in 1986, the astonishment remains.

Noting that "[t]here is no way for the interested music educator or researcher to stay abreast of all research in motor learning" (Sidnell 1986:11), Sidnell aimed with his questions to "... find those areas of research that hold specific promise for our work". Those questions which are of interest for the present study and not solely concerned with the developmental view[7] are reproduced in most instances *verbatim* below[8], while in some cases an attempt to further clarification is made by raising some more specific questions. Indications are given of whether the present study could play a role in addressing a particular question with respect to piano technique; it should however be kept in mind that the present study is not aimed in particular at resolving Sidnell's questions.

What is the relationship between motor learning and other forms of learning in music? Sidnell (1986:11) is interested here in the use of motor activities to develop sensitivity to musical stimuli, for example using big bodily movements like dancing (in children) to nurture an awareness of rhythm. It is usually intuitively assumed that an increased technical capability will provide a better opportunity for the performer's inherent ability for musical expression to be deployed to the full. But the question here goes deeper than this; as MacKenzie (1986:27) phrases it, "[i]s the motor system merely a slave for effecting a performance based on music knowledge, or is the motor system critical for the development and elaboration of music knowledge ...".

What application of current motor models should be made to music education? In Chapter 3, the two most important models of motor learning from motor systems theory, i.e. Adams' closed-loop theory and Schmidt's schema theory, are described, with in the latter case some results of attempts to apply the theory to the actual learning of music performance skills. In Chapter 2 the motor programming concept is dealt with, including some applications to certain aspects of piano playing. Whether the principles on which these theories are based are indeed valid - schema theory being highly dependent on the concept of the generalized motor program - is the question that will be

[7]For example the development of motor skills in very young children (Sidnell 1986:11-12).

[8]For purposes of clarity, each question is italicized.

addressed in Chapter 4, which is concerned with the action approach to motor control and learning.

Is there reason to believe motor patterns in music are different than other patterns? Sidnell (1986:13) raises the possibility that the nature of feedback[9] when learning motor responses in music may be different from the feedback received in the learning of other, non-musical motor skills:

> Since the "reals" of music are aural and perhaps less concrete, do feedback loops function differently? ... In order to establish testable hypotheses, should we apply available models or should we theorize differently?

What is the role of proprioception in small-muscle music responses? According to Schmidt (1988b:8), the term *proprioception* refers to "... the sense of body position and orientation thought to be signaled by the various muscle and joint receptors together with receptors located in the inner ear". Proprioception should be distinguished from perception in that perception deals with the environment; proprioception with the body (Gibson 1966:44). Sidnell (1986:12) notes that

> [w]e, in music education, have only a generalized knowledge about objectives of this type, and our teaching procedures are, for the most part, chosen without any understanding of this and other important phenomena in motor response.

How are the timing sequence and consideration of motor responses accomplished? What physiological mechanisms are at work? How do we make so-called automatic patterns from irregular sets of motor responses? The problem of understanding the coordination between the small limbs themselves, and between small limbs and larger limbs certainly is of a highly complicated nature. In a musical performance, the timing of muscle contractions and relaxations is also subject to the constraint posed by some external rhythmic requirement, i.e. that of the piece of music that has to be performed. While the present study is not aimed at a detailed understanding of physiological and neurological factors underlying motor behaviour, a theory of timing and rhythm in skilled piano performance - also applicable to other skilled performances - based on motor systems theory principles as proposed by Shaffer (1981, 1982, 1984), is discussed in the present study (see Chapter 2).

What can we learn about efficient motor practice? Sidnell (1989:12) here raises questions concerning *inter alia* practice lengths, rest between practice, and the effects of fatigue; these questions will be discussed in Chapter 5.

What is the transferability of motor skills? According to Sidnell (1986:12), it is common practice among pianists

> ... to develop high levels of technique on the assumption that there will be application to a

[9]The subject of feedback will be given some detailed treatment in Chapter 3.

> whole population of motor performance problems. ... Yet one can document countless hours in performance training where lack of pattern recognition retards the accomplishment of an accurate, complete motor response.

Some discussion will be devoted in Chapter 5 to the subject of transfer in general motor tasks, and possible applications to piano technique will be pointed out.

How does motor memory function? Most pianists have probably experienced that motor memory at times appears to function in a manner unconnected to any cognitive awareness. Although relatively little information on motor memory and retention has emerged from research on this topic in general, some discussion is devoted to it in Chapter 3 in the context of the motor systems perspective.

1.6 Overview of the thesis

Chapter 2 deals with the motor systems approach to motor control, with special reference to piano technique.

The concepts of movement and motor control will be defined. Piano technique will be classified in terms of the continuous/discrete/serial and the open/closed dimensions of motor behaviour.

In order to establish a foundation for a true understanding of theories of motor control in the context of the experiments from which they have evolved, two approaches to the quantification and qualification of movements will be described, namely the measurement of movement characteristics and movement outcome respectively. In order to render these rather general concepts more specific, a typical procedure for measuring aspects of movement outcome in piano playing will be reproduced.

Three presumed stages of information-processing in humans will be described, namely stimulus-identification, response-selection, and response-programming. The conceptual distinction, as well as its merits, between three structures for motor memory, i.e. the short-term sensory store, short-term memory, and long-term memory will briefly be looked into.

The current view that the concept of attention should be defined in terms of the interference between motor tasks will be explained. The earlier fix-capacity and the more recent pools-of-resources theories of attention will be described briefly. The influence of interference on attention during and after the three information-processing stages will be pointed out. The concept of automaticity between tasks will be defined, and the validity of the idea of controlled processing evolving through practice into automatic processing will be subjected to closer scrutiny.

In an attempt to make the theorizing about information-processing more relevant to the problems of motor skill execution in everyday life (including piano playing), the influence on information-processing of spatial and temporal anticipation will be considered. So will be, for the sake of completeness, the influence of stress and arousal on information-processing, with regard to which some subtleties will be pointed out.

The analogy of man as a computer prevalent among motor systems theorists will be investigated, and three mechanisms for motor control will be described, namely the closed-loop system, open-loop system, and feedforward control. The concept of a motor program will be defined, and some arguments will be presented to show where the concept originated from. The role of feedback during the execution of motor programs will be pointed out. The generalized motor program will be introduced as an improvement on the original concept. Certain problems of coordination in piano playing will be looked into and explained using motor programming notions. A motor programming basis for rhythm and timing in piano performance will be presented.

Reservations action theorists have with respect to the motor systems approach to motor control and learning will be dealt with.

Finally, a summary of and conclusions on the most important findings of the chapter will be presented.

Chapter 3 deals with the motor systems approach to motor learning, with special reference to piano playing.

The concepts of motor skill, motor learning and motor transfer will be discussed. The relative importance of three types of intrinsic feedback for piano playing will be examined; descriptions will be given of how aural, kinesthetic and visual feedback can be employed by the pianist. Knowledge of results and knowledge of performance will be singled out for discussion as particularly important modes of extrinsic feedback. The question on when knowledge of results should be given to the learner will be addressed, as well as the significance of kinematic and kinetic feedback and videotape replays as methods of giving knowledge of performance to the learner of piano playing.

The stages of motor learning will be identified. Two important motor learning theories will be discussed, namely Adams's closed-loop theory, and Schmidt's schema theory. Each model's representation of how learning takes place will be described. Logical inconsistencies and limitations of each theory will be discussed. Schmidt's theory was introduced to eliminate certain short-comings in Adams's theory; the nature of these improvements will be investigated. Strategies will be

identified for the practical application of concepts from schema theory to establish more effective musical instrument practice; some research findings to determine whether such strategies indeed lead to improvements in motor learning in music will be examined.

The subject of motor memory and retention will be looked into. Some possible theories of forgetting will be pointed out, and the relevance of the concepts of short-term and long-term memory will be examined. The significance of the phenomenon of warm-up decrement for piano playing will also be investigated.

Some conclusions will be made, and the most important findings summarized, in the final section.

In Chapter 4 an action systems view to motor control and learning is presented, with, where applicable, reference to the problems of piano playing.

The action systems approach to motor control as opposed to the motor systems approach will be briefly outlined. The distinction between functionally-defined actions and the traditional motor systems understanding of movements will be pointed out. Postures and movements as the subsidiary components of any action will be described; the piano playing method of Taylor employing the so-called expanding posture as the principal catalyst for piano technique, and possible common denominators between this method and action systems theory, will be investigated. Postural precedence effects will be discussed.

The way in which action systems and action cycles comprise human motor behaviour will be looked into; basic actions will be defined. Reasons will be investigated for action theorists regarding the phenomenon of tool use as an important questioning factor of motor systems premises; various examples will be cited from the literature on piano methodology to prove the notion that the hand is often seen as a tool in piano playing. The question of whether the dynamical systems approach presents a viable alternative to the motor programming idea of motor systems theorists will be investigated.

The ecological perspective advocated by Gibson on how humans obtain up information from the environment will be examined in broad terms. To avoid confusion, certain aspects of the relevant terminology will be clarified. The perceptual systems that appear to have relevance for piano playing will be looked into briefly.

Indications in the literature on piano methodology, that piano playing may be a goal-directed activity in the action sense, will be looked into. Emphasis will be placed on musical aesthetics as the

"goal", in relation to technique. Common denominators between Abby Whiteside's apparently functionally-orientated concept of technique and action systems theory will be investigated and commented upon.[10]

One or two action systems ideas on motor learning will be pointed out. Some remarks will be made on whether action systems theory indeed can account for motor learning in humans.

The chapter will be concluded with a summary of the most important findings, and some conclusions pertaining to these findings.

In Chapter 5 an investigation will be launched into how the different variables involved in motor skill practice are influenced by, and can be organized according to, the premises derived in earlier chapters from either the motor systems view and/or the action systems view on motor control and learning. Factors that may not directly pertain to earlier concepts, but are as important for practice, will be pointed out and briefly described for the purposes of forming a more complete picture of motor skill practice. Where appropriate, suggestions for piano practice in particular will be included.

Firstly, certain prepractice conditions that could enhance motor learning will be described. The roles of verbalized instruction, observational learning, verbal pretraining, knowledge of scientific principles and establishing a reference of correctness before practice begins as methods for developing a concept of the task will be examined. Some significant points on motivation will be discussed discussed.

The structuring of the practice session will be discussed with respect to variables that will include the number of practice trials, massed vs. distributed practice, the time involved in massed practice, variability in practice, and the importance for conditions of practice to resemble the conditions of the actual performance of the skill. Regarding piano playing, special attention will be given to the questions of practising rapid passages slowly, and practising problematic passages in varied rhythmical patterns.

The conditions under which maximum transfer from practising the task to its actual execution occurs will be subjected to scrutiny. Some fundamental principles of motor transfer will be pointed out. The question of practising a piece at the piano in parts vs. practising the whole will be looked into.

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[10]It is by no means suggested that the methods of Whiteside and Taylor, which are singled out for discussion in Chapter 4, are the *only* methods in the piano methodology literature displaying factors in common with action theory concepts. Rather, these methods were selected because they are documented fairly extensively, and appear to have been tested in practical teaching situations.

Some comments will be made on mental practice, which is often used by pianists, and the subject of guidance in piano playing.

Finally, conclusions will be reached on *inter alia* the ability and usefulness of the motor systems approach vs. that of the action systems approach to supply guidelines in terms of motor control and learning for structuring practice. Some of the most important findings will be summarized as well.

The present study will be rounded off with some final conclusions and recommendations in Chapter 6, based on the material presented in previous chapters.