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CHAPTER 5
CONCEPTS FROM MOTOR CONTROL AND LEARNING AS A BASIS FOR PRACTISING THE PIANO

5.1 Introduction

In previous chapters an attempt has been made to explain, in broad terms, both advantages and fallacies of the motor systems and action systems approaches to motor control and learning. The purpose of the present chapter is to determine whether it is indeed possible to extract from the maze of rather abstract concepts presented earlier, some useful information with regard to the structuring of activities and time spent at practising[1] the piano. According to Gieseking and Leimer (1972:46), perhaps *the* most important duty of the piano teacher is to teach the student how to practice; a teacher "... deserves the greatest praise if he untiringly points out to the pupil the best way to work". According to Owen (1988:84), efficiency in practice can be enhanced by a systematic method of instruction in practice techniques. Additional efficiency in musical instrument practice can be gained from instruction with respect to the role of schema in motor learning at the piano (see Section 3.4.2.7). It should be reiterated here that this chapter, like all the other chapters, is *not* concerned with the incalculable number of physical strategies that can be employed from the piano teacher or pianist's point of view for better scale playing, faster trill execution, and so on. Rather, the emphasis will fall on an effective way or ways to get such a movement pattern, once it has been decided on, "automaticised" as quickly and effectively as possible.

It has been stressed before in the present study, that extremely little empirically-based information on piano playing appears to be available. Thus, a worthwhile approach to the problem of applying motor behaviour science concepts to piano playing, would be not so much an attempt to present

[1]Radocy and Boyle (1979:312) allows for a rather wide definition of the term *practice*: "Depending on one's theoretical position, one may regard practice as exercising or strengthening stimulus-response connections, applying a learned response to a new stimulus, anticipatory goal-seeking responses, or searching for insight".

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indisputable truths, but rather to investigate if it is not possible to find discrepancies in views generally accepted by pianists and teachers because of tradition or habit. It is indeed a fact that to illustrate that "something is *not* as has been supposed" is also a contribution to any field of study.

In correspondence with the approach suggested by Schmidt (1988b:377), those variable parameters which can be directly controlled by the teacher or learner, will be concentrated on. Such an approach, of course, is in line with the generally behavioural level of analysis of the present study.

Finally, some attention should be given to the research area aimed at investigating how piano students structure their practising sessions by their own initiative. The purpose of such an approach is, of course, to obtain directions for practice with some amount of general applicability. In this regard, Gruson (1988:93) states that, although practice is without doubt the most critical aspect of the skill acquisition process, the behaviour of music students as they practise, is an area still left mostly uninvestigated. This problem was therefore addressed by Gruson (1988) in a study which investigated general[2] musical acquisition, by examining the behaviour in rehearsal of piano students varying in musical competence from the first grade to concert pianists. Gruson (1988:106) subsequently found that significant changes in practising behaviour takes place as students become more skilled as musicians -

> [e]rrors, repeated notes, and pauses tended to decrease with competence while self-guiding speech, total verbalizations, playing hands separately, time spent on each piece, and, particularly, repeating sections ... increased as music level increased. (Gruson 1988:101)

Across practice sessions, however, fewer behavioural changes occurred. At all levels of proficiency, tempo increased across practice sessions, the required tempo being attained earlier by the more advanced pianists. The most significant finding, according to Gruson (1988:106-107), was "... the change in the units of music repeated during practising as musical experience increased". In particular, as skill increased, students repeated sections of music more often, tending to use less notes at every repetition.

Gruson (1988:110) identifies an area for future research that could be of particular interest for students and teachers of piano alike:

> If it is indeed possible to isolate more mature or effective practising strategies, it would be interesting to investigate by means of a specific training programme whether practising is modifiable or whether it is purely a function of experience.

In the following sections various possible contributing factors to more effective practising strategies will be identified, while an attempt will be made to explain their influence on practice in

[2]I.e., motor aspects, although omnipresent, were not specifically isolated for study.

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terms of the principles of motor control and learning discussed earlier.

5.2 Prepractice conditions

The effectiveness of practice is influenced by some factors which are operant even before actual practising begins. The two factors regarded by Schmidt (1988b:378-379) as of the most significance will subsequently be discussed here; they are

- motivation
- developing a concept of the task

5.2.1 Motivational aspects[3]

Most learners and teachers know intuitively that motivation is important for engaging in effective practice, especially in view of the fact that the practising experience can be far removed from an emotionally satisfying one. As John Browning (Noyle 1987:26) acknowledges: "... every artist gets angry in practicing. ... So there are times that you hit the keyboard, and there are times you swear four-letter language. It's hard work. It's like dishwashing. It isn't fun." Two important determinants of motivation are briefly mentioned here. The first is the importance of making the task that is to be learned seem important (Schmidt 1988b:378). While the general interest in so-called "classical" music according to some observers appears to be declining, the question could be asked why it is worthwhile to spent hours a day practising the piano while the world around one essentially thrives on "instantaneous" happenings; it is possible, for instance, to establish communication to almost any place in the world within seconds. The second aspect has to do with the setting of goals[4]. Locke and Bryan (1966:286) found that the setting of performance goals in a psychomotor task resulted in intensified effort at all stages of activity. Schmidt (1988b:379) singles out for attention, that part of their experiment which involved one group being told to "do your best", while the other group was encouraged to strive for a higher level of achievement. It was found that the second group actually performed better than the first - although it is not certain whether this effect should be attributed to the learning process, or the temporal influence of motivation (Schmidt 1988b:379). What is certain, is the fact that the goal should not be set too high either, as this could result in the detrimental effects, associated with too much arousal, which were explained in Section 2.6.

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[3]Although the present study is not primarily concerned with the affective aspects of learning, it is nevertheless necessary to take heed of the motivation factor in motor learning, as neglecting it could jeopardize even a carefully planned strategy for practice.

[4]The word is not used here in the sense it was used in the discussions on action systems theory in Chapter 4.

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5.2.2 Developing a concept of the task

Schmidt (1988b:379 ff.) identifies five techniques for assisting the learner in "getting an idea" of the task to be mastered, namely

- verbalized instruction
- modelling of the task
- verbal pretraining
- knowledge of principles from physics and physiology
- establishing a prepractice reference of correctness

These subjects will now be subjected to closer scrutiny.

5.2.2.1 Verbalized instruction

While the limitations of verbalized instruction has already been pointed out in the introduction to the present study, it is nevertheless worthwhile to make some additional comments on this subject. Schmidt (1988b:379-380) is of the opinion that verbalized instruction can fulfil three tasks, namely to give the student an overall concept of the movement as guide to the first attempt, to help the student to recognize his own errors by "checking" on the spatial state of limbs during or after movements, and to make the student aware of what *not* to do. He then points out, however, that instructions are often overused in, and not entirely sufficient for, situations where learning is required:

> Words alone are relatively crude descriptions of the complex kinds of movements that a learner is attempting to achieve ... Only the most global, general aspects of the intended movement are going to be transmitted through verbal instructions. Also, a learner can remember only so many instructions ... (Schmidt 1988b:380)

Verbalized instruction of course abounds in the literature on piano playing. Townsend's description of what true "finger independence" should look and feel like - as quoted by Gerig (1974:364-365) - is perhaps an example of the nature and format of the information that the learner should receive before the practice session:

> True independence, cultivated to its highest point, gives the hand and arm a constant appearance of naturalness and grace, convincing the onlooker of a feeling of comfort in the player .... The training of the hand therefore, must, from the beginning of study be based upon the idea that movement in any finger which causes simultaneous movement in any other finger is not independent enough. Every finger-movement - to be a really independent one - must be made without occasioning the movement of any other part of the hand. The strictest inhibition of all other movements becomes then as important a matter as is the movement itself. But this inhibition is impossible as long as the weight of the hand and arm is incorrectly used, or, in other words, as long as the hand and arm are not balanced.

In the "balanced" state, the arm should display the following characteristics:

> The balanced state is that in which, when the fingers are resting on anything - in the present case the keyboard - the whole limb from shoulder to finger-tips is at any moment ready and

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> willing to swing: up, down, sideways, or circularly, at the wrist; or sideways at the elbows; and the problem to be solved by the student is, how to practise and at the same time preserve this condition of balance as a constant bodily habit. (Gerig 1974:365)

Finally, the apparently common practice among teachers, to define the different ways sound can be produced on the keyboard by employing verbal metaphors, should be noted. Neuhaus (1973:100) for example, in order to describe "freedom" in piano playing, compares the arm with a hanging bridge, the shoulder and fingertips being the bridge posts. However, as soon as the hand and fingers are raised above the keyboard, "... the image of the bridge is no longer accurate and it is better to think of a crane ...". The views on imagery of another staunch advocate, Abby Whiteside, were already pointed out in Section 4.2.9.2.

Unfortunately, it is not possible to give at this stage any empirically-verified indications of how a strategy for effective verbalized instruction should be organized, because "[e]xperimentation in motor learning has been negligent in this respect" (Schmidt 1988b:380).

5.2.2.2 Modelling of the task and observational learning

Modelling is often used along with instructions to aid the learning of motor skills. One technique of modelling employs "... movies, loopfilms, videotapes, or even photos of skilled performers" (Schmidt 1988b:380). Examples of the latter are found quite frequently in the literature on piano technique, for example the series of photos showing Annie Fisher playing the first three or so measures of Chopin's *Fantasie Impromptu* in Gát (1958:48-49), and the photos of the hand engaged in various activities in Schick (1982:17-20). But the most important type of learning based on skill demonstration is probably *observational learning*, to which this section will be devoted in its entirety.

The common approach to observational learning is to watch someone else perform. Almost all of the methods for piano technique, presented from the beginning of the eighteenth century through most of the nineteenth century, had as a basis the visual analysis of the motions involved in piano playing (Bridges 1985:19). The popularity of a visual analysis approach to the movements of the arms, hands and fingers in piano playing is easy to understand - sight is the only sense, apart from hearing, through which it is possible to directly perceive the playing of another person. It is furthermore far easier to describe movements that are visible, than to verbalize kinesthetic sensations as they are experienced by a specific person (Bridges 1985:19).

In spite of the fact that even everyday experience has proved that observational learning sometimes works, the field has been subject to some neglect due to, among other historical reasons, the fact that (Adams 1987:62) "... dominant fathers of the psychology of learning in the United States ... never

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had much luck with observational learning, and so learning operations that worked moved centre stage". Developmental psychologists have however always maintained an interest in observational learning "... because of their belief that children learn much of their language and social skills in that way" (Adams 1987:63).

Following Bandura (1977:22 ff.), Adams (1987:63) notes that the function of observational learning is to impart "... a cognitive representation (not a template) to the observer. The cognitive representation could be verbal, as with a verbal description of the model's behavior, or nonverbal, like an image." This cognitive representation can be used in two ways, namely

(1) to serve as a guideline for the actions of the observer when the observed behaviour must be reproduced

(2) to function as a standard of correctness for the detection of error between the response and the representation.

Adams (1987:63) identifies as a major reason for the field of observational learning being "incomplete", the fact that

> ... there are important dimensions of the movement that are unavailable to the subject's view. ... The cognitive representation is incomplete without these dimensions, and so the reproduced movement will be imperfect.

Examples of such unavailable dimensions are pressures executed by for instance the fingers in piano playing, muscular tensions, and external features of the movement that cannot be seen. Ortmann (1981:8-12) uses a vector diagram to represent the various forces that may be involved in producing a movement; even if the resultant, or observable, movement may appear simple, the "... composition of forces shows why the visual aspect of movement is not a safe guide to the muscular causes of the movement, since this may result from a few or many components" (Ortmann 1981:12). Gerig (1974:417) points out some more cases of "visual illusion", for instance the fact that no movement does not imply that no muscles are active - "... opposite sets of antagonistic muscles may be contracting against each other with equal force, rendering movement impossible", while Neuhaus (1973:103) observes that extensive practising of motor skills in piano technique - like scales - leads to movements "... hardly perceptible to the naked the eye". It is therefore not surprising that Lee (1977:3) regards the method of learning technical skills through visual and aural demonstration in private lessons and master classes, transferred in music teaching from generation to generation, as

> ... a rather ineffective and uninnovative approach, especially in an era in which educational philosophy constantly evokes new trends as educators search for more effective and efficient methods to match the advancement in science and culture.

However, "... ingenuous ways might be devised to make the unobservable observable" (Adams 1987:63), as was demonstrated by Carrol and Bandura (1982), who made use of a television system to make observable that parts of a complex arm movement that are normally obscured; the usefulness

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of a close-up filming of the fine muscle movements of a skilled pianist remains an option to be investigated.

Observational learning is not only concerned with watching accomplished performances. In passively watching a model *learn*, an observer will see the model's behaviour change over trials, and "... something undoubtably will be learned" (Adams 1987:63).

But when the observer in addition gets insight into the model's knowledge of results, he "... not only forms a cognitive representation but can join the model in other cognitive activities as well". (Experimental findings have indeed shown that the benefits obtained by a test group of observers, who watched a model learn with information on the model's knowledge of results, were "more stable and enduring" than those associated with a test group which only observed the model learning). The observer can use his developing cognitive representation of what is required in a skilled performance in order to identify errors in the response of the model. This perception of error can subsequently be checked against the knowledge of results that the model receives. The next step for the observer will be " ... to use this error information to project the correction required on the next trial and then, on the next trial, see whether the model did it".

The idea of observational learning by watching another performer learn with insight into his KR and KP - combined with the additional dimension of listening - certainly is not new to the field of piano playing. In this regard Fleisher (Montparker 1986:7-8) recalls picking up valuable information from attending the lessons of co-students of Artur Schnabel; he even holds the notion that the observer, because he is not under pressure to perform at that moment, is likely to be more than usually perceptive in such situations of learning.

Finally, it should be stated that how much actually can be learned through observation - with or without making observable the components of a movement that are normally obscured - is still unknown, and thus the hypothesis that "... a cognitive representation acquired by observation is inherently impoverished and incapable of wholly governing a refined, expert skill" has neither been fully proved, nor disproved, empirically (Adams 1987:63-64).

5.2.2.3 Verbal pretraining

Schmidt (1988b:422) defines *verbal pretraining* - which is somewhat of a misnomer since this type of preparatory training is not necessarily verbal - as "[t]he presentation of stimulus or display elements of the task in isolation so that they can be more easily responded to in later whole-task performance". On such presentations of stimuli, the learner would be expected not to merely watch

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passively, but to respond in a mode different to what the manner of response would have been in the actual execution of the task (Schmidt 1988b:382). An example would be a racing car driver exploring the race course by foot, verbally responding to questions on the outlay of the course.

A similar approach could benefit the pianist, for whom the keyboard is analogous to the race course in the previous example: Kochevitsky (1967:42), for example, points out the rather subtle fact that, due to the arrangement of black and white keys on the keyboard, harmonically identical intervals "... sometimes requires not only different positions of the fingers (depending on black and white keys), but also different stretches for similar intervals and similar combinations of white and black keys". Kochevitsky illustrates this point by presenting the different widths of three cases of minor thirds with the ground note on a white key and the other note on a black key, i.e., f - $a^{\flat}$ = 35 mm., c - $e^{\flat}$ = 38 mm., g - $b^{\flat}$ = 39 mm. Thus it could be worthwhile for especially small-handed pianists to keep in mind, when attempting high-speed arpeggio playing, that slight differences do exist between apparently similar arpeggios, like F Minor and C Minor.

5.2.2.4 Knowledge of principles from physics and physiology

The idea that knowledge of the physiology of the playing apparatus of the pianist can help to enhance planning a strategy of practice is certainly not new; the extensive research done by Ortmann (1981) and the emphasis placed on physiology in their technical treatises by *inter alia* Gát (1958), Ching (1946) and Fielden (1961) testifies to this. Fielden (1961:8) in fact regards as shortcomings in the methods of Breithaupt and Matthay - the latter after which "... the English pianistic world would never be quite the same" (Gerig 1974:398) - the fact that

> ... neither of these men ... sufficiently emphasized the necessity for scientific knowledge of physiology, and the relations and co-ordinations of muscular actions; nor did they insist enough on a knowledge of the laws of mechanics, as far as the application of the laws of leverage was concerned.

Gerig (1974:413) notes that the criticism was raised, "particularly among emotionally dominated pianists", that the scientific approach of Ortmann to piano playing would adversely affect its aesthetic component, the sciences being of a "cold"[5], unemotional nature; Schultz (1936:vi) mentions the existence of a

> ... half-conscious and almost universal suspicion that there is a fundamental incompatibility between a mind interested in the mechanical phases of playing and a mind filled with what is loosely known as musical temperament

[5]Ahrens and Atkinson (1955:36) whole-heartedly endorse a scientific approach to piano playing. Yet this laudable fact does not save them from making the rather enigmatic statement that "... we should always be able to accept *hard, cold facts*" (italics added). Facts, as can be attested by any person familiar with them, are hardly ever experienced as "hard" or "cold".

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Gerig (1974:413) points out that one of the true reasons for this aversion with respect to the scientific approach was rather that "[i]t was quite likely ... that pet theories might be destroyed".

According to Neuhaus (1973:87), an attempt to a more general and accurate terminology should not be regarded as intervening with or undermining the "spiritual", or aesthetic, facet of music -

> ... let this [not] worry those who hold the "mystery" of art so dear: the mystery of art remains unfathomed, retaining all its force and scope, just as in life. But one should not see the "unfathomable" where common sense, against which we all of us sin so much, can perfectly well understand all there is to understand.

An approach to technique that illustrates how seemingly abstract principles and concepts of mechanics can be used to explain matters of piano playing, is that of Neuhaus (1958:86-87): in his lessons, Neuhaus used from physics the symbols *F* (representing force), *m* (mass), *h* (height) and *v* (velocity) - relating them to the playing apparatus of the pianist - as an aid to his students for "... understanding and using the physical possibilities of the piano, considered as a mechanism"[6]. In fact, he regarded the cultivation of the ability to view piano-technical problems from such an angle, as an integral necessity to the pianist's make-up (Neuhaus 1973:87):

> ... the better a pianist knows the three components ... first the music, secondly himself and thirdly the piano ... the greater the guarantee that he will be a master of his art ... . And the greater his ability to formulate his knowledge with precision in statements even remotely akin to mathematics and that have the force of law, the more profound, sound and fruitful will his knowledge be.[7]

In spite of the arguments in favour of knowledge of principles from physics or physiology underlying piano playing, it nevertheless appears as if some pianists fare quite well without such knowledge, becoming highly accomplished at their instrument. Due to lack of empirical information in general on the influence of knowledge of such principles on practising, it is not possible as yet to make any definitive statements on the subject at the present time (Schmidt 1988b:383).

5.2.2.5 Establishing a reference of correctness before practice commences

Of most interest for establishing a prepractice reference of correctness for piano playing is perhaps

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[6]Neuhaus (1973:110), for example, suggested that pianists with small hands, could circumvent the problem of playing loud chords with considerable stretch, by replacing great *h* with *v*.

[7]The warning should however be exerted here that a superficial knowledge of physics will not be of much use either. Thus, for example, Taylor's (1979:43) confusing statement, apparently derived from one of Newton's laws of motion, that "[t]o every action, there is an equal and opposite reaction, therefore the resistance of the seat must at least equal that of the piano mechanism under its heaviest stress" should rather remain unsaid. Even more peculiar is the notion by Taylor (1979:55) that "... nearly all the energy expended on key-depression is returned to the performer by the rebound of the key ... [t]he total activity of a coordinated performance may therefore be expressed as a two-way flow of energy between the performer and his instrument". At the most the rebound of the key can be used as an opportunity to *save* physical effort in the sense that it is not necessary to purposefully lift the finger in order to release the key; i.e., it is sufficient to let the rebound of the key push the finger back to its original position.

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the *Suzuki* approach to violin playing, where the reference of correctness is formed by repeated listening to a model performance before practising begins (Schmidt 1988b:383)[8]:

> Presumably, as the student attempts to play, he or she compares the sounds actually made against the reference of correctness established by the recorded violin music... Deviations in the student's own reference of correctness suggest errors that must be corrected in subsequent attempts.

Kerr (1982:300), however, is of the opinion that, "... because this is a commercial technique rather than a laboratory-verified procedure, it is difficult to assess its validity".

5.3 Structuring of practice

In the following sections, eight diverse variables will be pointed out which should be kept in mind when structuring a practice session will be discussed. Most of these aspects as identified by Schmidt (1988b) pertain to the practice of motor skills in general, but some have direct bearing on piano practice. These aspects involve:

- the number of practice trials
- massed vs. distributed practice
- the time involved in massed practice
- variability in practice
- blocked vs. random practice
- the resemblance between the conditions of practice and the conditions of transfer
- slow vs. fast practice in acquiring piano-technical skills
- practising in varied rhythmical patterns

5.3.1 On the number of practice trials

There seems to be agreement among psychologists and musicians alike that the more practice trials, the more learning will occur[9]; Schmidt (1988b:384) notes that "[i]n structuring the practice session, the number of practice attempts should be maximized", while the maxim *repetitio est mater studiorum*[10] is supported by *inter alia* Gieseking and Leimer (1972:81) and Neuhaus (1973:147). The question of how the maximum number of repetitions should be fit into the time available to the learner, is addressed below.

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[8]Apparently, this strategy is not adhered to in Bigler and Lloyd-Watts's (1979) application of the Suzuki method to piano teaching.

[9]Assuming that these trials are not performed half-heartedly, but with a full effort of all facilities required.

[10]Repetition is the mother of study.

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5.3.2 Massed vs. distributed practice

Massed practice can be described as (Schmidt 1988b:422) "[a] sequence of practice and rest periods in which the rest time is less than the practice time", while *distributed practice* is "[a] sequence of practice and rest periods in which the practice time is less than the rest time".

Most research on massed versus distributed tasks has been done with respect to continuous tasks. An unanimous finding was that the limited rest periods associated with massed practising, lead to a systematical decrease in performance compared to distributed practice, where more time for rest is allowed (Schmidt 1988b:384). Apparently, empirical results have shown that performance is severely affected by massing, but learning far less so (Schmidt 1988b:386), a finding which immediately gives rise to the question

> [h]ow can learners practice a task under massed conditions, when performance is clearly inferior to that experienced under distributed conditions, and yet learn just about as much? These effects seem clearly contrary to intuition, as it would seem that fatigue associated with massing would cause people to learn the "wrong" movements.

Schmidt (1988b:387) presents two hypotheses to clarify the matter: the first is that massed practising actually induces variability in the movement patterns that are practised, which leads to more effective learning, as will be explained in Section 5.3.4. The second hypothesis holds that massed practising requires more effort to master the task, thus causing more thorough processing.

Although some thought-provoking results have been obtained for the effects of massing on discrete task practising - studies have shown that massing does not necessarily impair performance during the acquisition phase, and it has even been found that massed practice increases the quality of performance, Schmidt (1988b:388) notes that it is "... probably premature to generalize very strongly from these ... studies". It appears, however, that the discrete tasks studied here would rather be relevant to skills like kicking or throwing, rendering them for the present not of critical importance to piano playing.

5.3.3 The time involved in massed practice

Apparently, no clear, empirically-based rules exist for determining how long a practice session should continue. According to Schmidt (1988b:390), experimental findings suggest that "... the most effective schedule for learning motor skills will be dependent at least in part on the energy cost of the task". Thus, a task that requires a high input of physical effort would be most effectively practised in a shorter period than a task which requires less effort; the same probably applies with respect to mental effort as well.

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It should however be emphasized that "... a single, optimal distribution of practice and rest periods does not exist, and that this choice will depend on the task to be learned" (Schmidt 1988b:390).

Views by different pianists and pedagogues seem to support the above statement; Gieseking and Leimer (1972:48), for example, holds that "[t]o practice the piano five, six, or seven hours daily is generally done without concentration and is at the same time injurious to the health". André-Michel Schub (Noyle 1987:109), however, appears to differ:

> ... I practiced as many hours as I physically could. I have to admit more than six or seven hours a day. ... I know that other people did it, too. ... With the piano, there's no way of getting around those hours at the piano if you practice to play correctly.

5.3.4 Variability in practice

In Section 3.4.2.4 schema theory has been used to explain why variability in practice of motor tasks should benefit learning. Some additional remarks with regard to variability in practice will subsequently be made.

It appears rather obvious that to practice open tasks[11] under varying conditions would be beneficial to the learning of these tasks. Yet experimental evidence has implied that closed motor skills might also benefit from being practised in different ways, with variable practice increasing the degree to which the learned skill can be applied to novel variations of the task learned. Schmidt (1988b:394) sums up the findings so far on variability in practice as follows:

> ... when adults are used as subjects, there is reasonably strong evidence ... that increased variability is beneficial for learning as measured on novel transfer tests, and basically no evidence that variable practice is detrimental to learning. But there are a number of studies which show very small effects, and others with essentially no effects, which cast some doubt on the "strength" or generality of these effects.

Thus it appears safe to say that practising piano technique could benefit from variability being introduced in some way into the learning process; with respect to which aspects of practising such variability should pertain is however not certain.

In a somewhat different vein, Owen (1988:85) suggests that practice, varied in the sense that attention is focused on different aspects of the task, should serve to develop as many schema (in the sense described in Section 3.4.2.7) as possible;

> differing images result in differing schema, and differences in performance. For example, a phrase might be thought of by its melodic direction, its dynamic contour, its relation to surrounding phrases, or by the kinesthetic feel of playing it. Each of these could produce a

[11] I.e., tasks for which the environment is constantly changing.

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different schema, resulting in differences in performance.

5.3.5 Blocked vs. random practising

Studies of *context effects* have mostly been concerned with factors that make the task to be mastered more difficult for the learner than is actually required (Schmidt 1988b:395).

An area of major interest is that of *blocked vs. random practice*, which deals with problems of the following type: three tasks, namely a certain scale, arpeggio and scale in double thirds have to learned. Which practising strategy would be the most efficient - practising ten trials of the scale followed by ten trials of the arpeggio followed by the same amount of trials of a double note scale, or changing the task on every trial? An experiment similar to this situation in organization[12] - but vastly different with regard to the type of motor tasks that had to be learned - by Shea and Morgan (1979), is cited by Schmidt (1988b:396) as representative of some noteworthy findings on the question of random vs. blocked practice. While performing the trials in random order in the acquisition phase, which resulted in an overall slower performance than was found for the group learning the trials in blocked fashion, the random group actually performed better in transfer tests, i.e. after periods of retention (in this case ten minutes and ten days respectively). Schmidt (1988b:396-7) describes this finding as

> ... curious ... especially when we realize that the Random condition in acquisition resulted in slower performances than the Blocked condition. This is another instance in which the conditions that *improve* performance in acquisition seem to degrade learning as measured by performance [after some time lapsed] ... *This certainly runs counter to the general idea that, in practice, we should always attempt to organize the conditions so that performance is maximized.* [Italics added]

One hypothesis for explaining the effects of random vs. blocked practice is that each type of practice involves a different level of processing. While subjects involved in blocked practice apparently tend to execute the movements without much thought, it is critical for the random group, for which each task changes from trial to trial, to establish a meaningful understanding of the tasks, as well as concepts of what make them different from each other (Schmidt 1988b:398). Thus the "deeper" processing by the random group apparently lead to a better learning of the task. Another hypothesis, the so-called *forgetting hypothesis,* stresses the generation of the appropriate motor program as the critical component of the learning process:

> ... random practice causes the subject to forget the "solution" to a given motor task, so that

[12]This experiment had as the three movement tasks three variations on a task which in its basic form required that the subject had to grasp a tennis ball in a start position, knock over, in a prescribed order, a series of barriers as fast as possible, and place the ball in its finishing position. Variations consisted of changing the locations and number of barriers; subjects however received some indication of the spatial organization of barriers (Shea & Morgan 1979:180-181).

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the solution must be generated [anew] when that task is presented again. (Schmidt 1988b:398)

Of course, it is also possible to employ schema theory for an understanding of the random vs. blocked practice phenomenon, as random and blocked practice can essentially be considered two types of practice with different degrees of *variability*, the former having greater variability than the latter. Schmidt (1988b:399), however, points out that variable practice may not be such a strong premise for schema theory to claim correctness; "... variable practice in relation to schema theory could really be nothing more than context effects, and might be more effectively explained by the depth-of-processing or forgetting hypotheses ...".

If assumed that random vs. blocked practice effects, which "... seem to represent stable and dependent principles of motor learning" (Schmidt 1988b:399), are applicable to the learning of the motor skills of piano technique as well, it should be one of the major shaping factors of the practice session. As Schmidt (1988b:400) appropriately, but with some caution, declares -

> [t]he "traditional" methods of continuous drill on a particular action (i.e., practicing one skill repeatedly until it is correct) is probably not the most effective way to learn. Rather, ... practicing a number of trials in some nearly randomized order will be the most successful in achieving the goal of stable learning and retention. ... [m]uch work on these issues needs to be done, however, with different kinds of tasks and various training settings, before we can be confident about how to effectively apply these principles.

This warning should be kept in mind when structuring practice along the lines advocated by the *repetitio est mater studiorum* protagonists (see Section 5.3.1).

5.3.6 Resemblance between the conditions of practice and conditions of performance

On of the most common problems in the structuring of practice sessions is perhaps best described by the following practical example: should the difficult coda of the third movement of a concerto be practised at the end of a session of massed practice when the learner is fatigued and performance is down - which could very well be the case in the actual public performance, the movement being the final one - or should it be practised under rested conditions?

The *specifity-of-learning hypothesis* holds that practising should occur under conditions resembling as closely as possible the actual conditions under which the performance will take place (Schmidt 1988b:422). While, according to Schmidt (1988b:401), many studies tend to favour the hypothesis, its

> ... effect is often very weak, however, and does not seem to make much difference. In addition, the effects are sometimes *asymmetrical*; that is, for transfer Condition A it is far more effective to have practiced under Condition A than B; but for transfer Condition B it is only slightly more (or no more) effective to have practiced under Condition B than A.

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Some contradictory results have also been found, for instance that in transfer of learning, Condition A is more effective if the task was practised in a different Condition B rather than Condition A. An example of such a result is that random practice conditions for the acquisition phase is always more effective, regardless whether the task is performed in transfer under random or blocked conditions.

As the specifity-of-learning hypothesis clearly does not envelop the most effective approach to all situations of learning concerning the acquisition phase, attention will now be focused on the viewpoint of *transfer-appropriate processing*, which states that (Schmidt 1988b:422,401)

> ... practice should be arranged so that the *processing capability* [italics added] learned is appropriate for some goal criterion task or conditions...it is the similarity of the underlying *processes* (not simply the *conditions*) between acquisition and criterion transfer performance that will be the critical determinant of the "goodness" of practice.

Thus, allowance is made for conditions in acquisition and transfer to differ; it is more important for the designers of training to understand the *processes* underlying the actual performances, and to attempt to cultivate these processes in practice (Schmidt 1988b:402). Unfortunately, the nature of these processes that should be learned "... still must be discovered by our research" (Schmidt 1988b:402); for the purposes of structuring practice at the piano, it is only possible at this stage to take note of the fact that apparently practice and concert conditions do not necessarily have to match in order to ensure a successful performance.

5.3.7 Slow vs. fast practice for acquiring piano-technical skills

According to Neuhaus (1973:90), the old and well known principle of practising *slowly and with force* has remained in widespread use, being especially useful for acquiring the ability to produce sound of large volume as required in pieces like the Rachmaninov Third Piano Concerto. Peter Orth (Elder 1979:20), for example, recalls how his teacher, Adele Marcus, taught him to practice the Chopin *Etudes* Op. 10 No's. 5 and 12 "... very slowly, triple forte". However, the following physiological considerations should be observed when practising slowly (Neuhaus 1973:91-92):

> ... make sure that the hand and arm, from the wrist to the shoulder, are completely relaxed, that there is no contraction, no "freezing" or stiffening anywhere, that none of the potential flexibility is lost, and at the same time remain perfectly still, making only those movements which are absolutely essential ... [U]se pressure only when the simple weight of the inert mass is insufficient to produce the desired volume of tone; understand that the greater the height ... from the which the note is played ... the less pressure or effort is needed.

For Gieseking and Leimer (1972:47), one of the most important advantages of slow practice lies in that it helps the student to avoid mistakes - for instance inappropriate movements and fingering - from the outset of learning a new piece; thus Reubart's (1985:85) notion that slow practice should only be "[a]s fast as you may wish *without errors*".

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Equally well known, however, is the fact that slow practice could establish habits not suited to the coordination required for speed (Whiteside 1961:54). Schnabel (1972:173), as well, was against any form of habitual slow practising of fast passages, including "... the old device of practising even semiquavers as dotted rhythms of one kind or another" (see also Section 5.3.8).

Whiteside (1961:55) also holds that "[p]ractice perfects exactly the coordination that it uses and not something else". Of particular significance from the psychological perspective, therefore, is Handel's (1986:19) proposal that, because rhythmic organization changes at different tempos, "... the type of motor learning and type of motor program also changes at different production rates. The relationship between motor learning and music education therefore should differ across tempos." As chief motivation for this statement, he presents some findings from his study on how polyrhythms, consisting of incompatible pulse trains, are perceived when factors such as the frequency of the notes comprising each pulse train, the duration, and/or the loudness of these element notes are changed. The highly significant conclusion Handel (1986:19-20) reaches, pertains to

> ... the perceptual nature of rhythm. A slow-moving pulse train in which the inter-element interval is greater than 1 s cannot provide the sense of regularity necessary for rhythmic perception. The elements appear unconnected and disjointed. Conversely, a rapid pulse train in which the inter-element interval is less than 200 ms moves to the foreground; it becomes the *figure* (with subjectively accented elements) and cannot serve as the rhythm. ... In other words ... [w]e cannot expand or contract a music pattern in time and expect to hear the same rhythmic structure.

These results seem to be confirmed by findings obtained by Duke (1989) in experiments which required music students to tap the perceived beat or pulse in response to periodic stimulus tones. According to Duke (1989:61),

> [r]ates greater than 120 tones per minute (tpm) were apparently "too fast" to be perceived as beat notes, and pulses slower than 60 tpm seemed "too slow".

The main implication of this finding for learning of motor skills at the piano pertains to aural feedback. Suppose the learner is used to practice slowly; if his perception of rhythm changes at speeding up the tempo to resemble more closely the tempo that will be required in the actual performance, the learning process might be disrupted, because (Handel 1986:20)

> [t]he performer might be "captured" by the perceived pattern. The performer would be unable to perceive alternate organizations and be unable to create the motor programs necessary to achieve those organizations. Moreover, the performer might make timing changes to bring about the desired rhythmic organization when played at one speed, but these changes would yield different rhythmic organizations when played at a slower or faster speed. *Practising a pattern at a slower rate might be counterproductive.* [Italics added]

Another matter that arises here is that of the degree of transfer that takes place when it is required that a piece that has been subjected to some careful slow practising, has to be executed at high speed. Handel (1986:20) is of the opinion that motor patterns - and the motor programs they are controlled

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by - can be divided into different categories which correspond to different rates of execution; thus the amount of transfer "... would depend on the similarity of rates and whether the change in rate crosses a motor pattern boundary". This view of course does not agree with Schmidt's understanding of the generalized motor program[13], where the overall execution time, and thus the overall tempo, is regarded as a variable parameter of the program - the only invariant temporal aspect being the relative phasing of the movements. As another example to illustrate that the generalized motor program theory is not valid for many motor skills, Handel (1986:21) cites the common motor skill of speaking: "[h]ere, too, we do not find an across-the-board slow down or speed up of articulatory movements. Instead, at faster speaking rates vowels are sacrificed for consonants to insure intelligibility." Handel (1986:21) sums up his argument on the ability of motor programs to expand and contract motor skills in overall execution time as follows:

> ... there may be general limitations in the ability of a performer to change the performance rate: alternate perceptual organizations might emerge which conflict with the desired organization and new motor programs might be required to perform at the different rate.

5.3.8 On practising in varied rhythmical patterns

Finally, it should be pointed out that the arguments listed in the previous section for slow practice are probably just as valid for the method of practising in "rhythms", which can be considered a special form of slow practice. In view of the argument that different motor programs are required for different tempi of execution, Kochevitsky's (1967:41) viewpoint that "... using numerous and diverse rhythmic variants in scales and exercises created out of actual musical situations is a very good means for mastering ... timing", i.e. timing of successive finger movements with "the finest precision", does not ring true here. Taubman (Schneider 1983:20) has some noteworthy views on this subject which, probably unwittingly, apparently take into account the findings of Handel discussed above:

> The real issue is being able to play ... [fast] notes evenly, as written. What is the value of distortion? If there is unevenness, figure out which finger is not getting enough support from the arm. In all such problems it is important to listen and train the ear to hear the even spaces between notes. Practicing uneven notes does just the opposite.

Or as Ashkenazy (Noyle 1987:7), rather candidly, notes on the practice of mechanical exercises, "I don't have a routine prescription or something like distorting the rhythm"...[14].

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[13]This subject was explained in Section 2.8.4.

[14]Then, again, there are pianists who do ascribe to practising in rhythms, for example André-Michel Schub (Noyle 1987:112).

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5.4 Conditions of practice and transfer

The concept of transfer of learning, which has to do with the gain (or loss) in effectiveness in one skill as a result of practice on some other has already been mentioned (see Section 3.1). Many piano teachers believe that practising mechanical drill exercises, like those by Hannon, will transfer positively to the technical problems encountered in pieces from the repertoire. Another common assumption is pointed out by Schmidt (1988b:407), namely that practising component parts of a task will transfer to the whole task.

In the following sections, a motor behaviour science view based on Schmidt (1988b) to these and related matters will be presented.

5.4.1 Basic principles of transfer

According to Schmidt (1988b:407-410), three principles of transfer of motor skills that can claim some measure of generality can be identified. Until some empirical evidence is gathered, however, it remains unsure whether these principles are indeed partially or wholly applicable to the complex processes involved in the learning of piano-technical skills. Some discussion is nevertheless devoted to these general rules in view of the lack of more specific information. They are:

- "motor transfer is small"
- "transfer depends on similarity"
- negative transfer

5.4.1.1 "Motor transfer is small"

According to Schmidt (1988b:407), studies which investigate the transfer from one task to another, completely different task, typically show that "... the transfer is small or negligible". In this regard, he interprets results from experiments by *inter alia* Lindeburg (1949) to have shown that

> ... "quickening exercises" (various laboratory tasks that require rapid decision and action) provide no transfer to other tasks that require quickness. This is certainly not surprising in light of what is known about the specifity of motor abilities, as the activities in the quickening exercises probably used different motor abilities than the task to which the exercises were supposed to have contributed.

Even where similar tasks were concerned, with only a variation in the performance speed requirement, it was found that transfer was small, though higher than in the previous case (Schmidt 1988b:408). As a matter of interest, the following related remark by Lindeburg (1949:194) is added here:

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> Definitely disproved is the theory that "quickening exercises" or sports activities (such as table tennis) that involve many rapid skillful movements improve the individual's general coordination.

The possible explanation of this phenomenon in terms of motor *abilities*, or the "[s]table characteristics or traits, genetically defined and unmodifiable by practice or experience, that underlie certain skilled performances" (Schmidt 1988b:342) should be expounded upon: Schmidt (1988b:408) states that

> ... motor abilities are both numerous and specific and ... even similar tasks appear to correlate very low with each other. If so, then in transfer experiments when the task is changed in even a small way ... it is likely that different and unrelated abilities are called into play ... there might be a low transfer among even very similar tasks because the abilities are almost completely different.

These observations are of extreme importance for the structuring of practice for piano-technical skills. As was pointed out earlier, it is a widely accepted approach to practice passages that will require great speed in execution slowly at first, even after the notes have been memorized. The finding that different abilities come into play for slow and fast execution, or even execution at rates that differ only slightly, appears to support the motor programming-based notion by Handel, described in Section 5.3.7, that slow practising does not necessarily enhance fast playing.

5.4.1.2 "Transfer depends on similarity"

The notion that the amount of transfer depends on the similarity between tasks is not a new one (Schmidt 1988b:408); it is however not clearly understood

> ... what "similarity" is, and what the "elements" are that are supposedly similar in various tasks.

It has been implied that "elements" could be, among other possibilities, abilities that are common to both motor tasks, and/or the motor programs that control the execution of both tasks.

In piano playing, tasks could display some similarity in a topographical sense, for example the ability to play an Alberti bass accompaniment based on the triad C-E-G, should imply that the same figure could be played if based on the triad F-A-C (it is assumed at the C and F in question lie in close vicinity on the keyboard). While the arpeggios F Minor and C Minor appear to be topographically similar in the sense that similar configurations of white and black keys are pressed, the subtle differences between key distances as pointed out in Section 5.2.2.3 should not be ignored.

In general, however, this matter remains enveloped in uncertainty (Schmidt 1988b:409).

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5.4.1.3 Negative transfer

Negative transfer can be described as the losses that occur in one skill as the result of the experience of another (Schmidt 1988b:409)[15]. An example of negative transfer proper[16] is the difficulty experienced by learners of a second language to produce its speech sounds, a difficulty which is to a large degree related to the characteristics of sound production of the speaker's first language. Schmidt (1988b:411) notes that speakers whose mother tongue is French or German have different problems when it comes to producing speech sounds from English; one would thus refer to these difficulties as representing negative transfer from French or German to English. Of some interest for piano technique could be an experiment performed by Shapiro (Schmidt 1988b:410):

> ... subjects [were instructed to] learn complex patterns of movements with a particular experimenter-imposed timing. Later, subjects were instructed to speed up the movement, which they had no trouble doing. But when they were also told to *ignore* the temporal pattern they had learned earlier, subjects had a great deal of difficulty producing a new temporal structure. Instead, they sped up the original temporal structure, more or less as one would speed up a phonograph record.

These results are not completely surprising, though, when viewed form the generalized motor program viewpoint, according to which it would be necessary to construct an entire new program to incorporate a different temporal structure. The question arises here once again of whether practising technically difficult scale passages in varied rhythmical patterns[17] at a slower pace than required, could transfer negatively to the actual performance, where the tempo has to be accelerated and the passages performed without any rhythmic distortion, thus involving an adjustment to the temporal organization of the task. Lack of empirical investigation into this matter precludes conclusive answers.

5.4.2 Practising the whole vs. practising in parts

It is almost customary for learners of piano playing to "break up" the whole piece into parts in order to concentrate on the most problematic passages, while eliminating cumbersome repetition of the simpler parts. Thus Newport (1982:33), in a manner typically found in numerous pedagogical treatises, states that "[t]eachers should demonstrate how to practice carefully: hands together, hands alone, small sections, and only what is needed". Gieseking and Leimer (1972:26) follow suit: "[o]nly small parts should be practised at a time; and these should be repeated over and over again, so that irregularities and unevennesses may be immediately corrected". Also, intuition dictates that

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[15]This topic has already been subjected to some brief scrutiny in Section 3.1.2.2.

[16]Where detrimental performance is not partly or fully caused by other factors such as cognitive confusion about what is required in the task.

[17]This topic was discussed in Section 5.3.8.

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practising a part should transfer to the whole, in view of the fact that the elements within the part stays the same, whether it is seen in isolation or in its context in the whole piece.

Schmidt (1988b:413), however, raises some reservations:

> The problem with this idea is that practice on the part in isolation may so change the motor programming of the part that it is, for all practical purposes, no longer the same as it is in the context of the total skill.

Taylor (1979:32-33) also raises an objection, namely that practising in parts divorces technique from the realities of making music. In particular, by dividing technique

> ... into different compartments [corresponding to different problems in the work], one mechanism for finger passages, another for thirds, another for octaves ... the busy pianist is constantly practising the very opposite of that simple continuous flow of gesture with which the talented performer follows the line of a work.

Taylor (1979:72) furthermore points out that, once coordination has been established through the method of Thiberge by using the expanding posture (which was outlined in Section 4.2.2.3),

> ... there is no question of chopping a work up into bits and pieces for the sake of 'practising'

provided that the pupil has formed an adequate mental conception of the work. This point of view is shared by Whiteside (1969:26), according to whom a so-called natural, or effortless, coordination is never put together after all the parts have been practised separately. However, Gieseking and Leimer (1972:48), unabashedly contradicting Taylor and Whiteside, state that

> [t]he objection that it is better to practice only complete phrases instead of dividing them up, does not hold good. ... [Division into parts] is not in the least harmful to musical feeling. On the contrary, the thorough mastering of short parts of a phrase at a time will enable the pupil to bring the complete phrase to a state of greater perfection.

In order to throw some more light on this intriguing question, it is necessary to conduct the investigation in terms of the two classes of movement tasks which have relevance to piano playing, namely serial tasks and continuous tasks.

For serial tasks, it appears as if the whole task can benefit considerably from practising the component tasks in isolation; it has even been found that spending a specific amount of time on practising components in isolation, could benefit the actual performance more than spending the same amount of time on the whole task (Schmidt 1988b:414). While the whole task can simply be reassembled from the different parts worked at in isolation, Schmidt notes that a more effective method seems to be that of *backward chaining*, "in which the last element in the sequence is systematically preceded by earlier and earlier parts until the whole chain is completed".

Schmidt (1988b:415) explains the implications of practising parts extracted from continuous tasks as follows, taking account of the fact that in certain tasks, for instance piano playing, different parts are often executed by different hands at the same time:

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> For continuous tasks, in which the behavior continues more or less uninterrupted ... the parts that can be isolated frequently occur at the same time as other parts ... Also ... the parts must frequently be *coordinated* with each other, and it might seem that breaking into this pattern of coordination to practice a part might not be very effective, as it is the coordination between these parts that must be learned.

Hence Schnabel's opposition to the practising of hands apart (Wolff 1972:173).

Schmidt (1988b:416) continues to note that, for motor tasks, like piano playing, involving the simultaneous execution of different parts, "[t]ransfer research ... is nearly non-existent ... and the decisions about part-whole transfer are merely speculative". Hence little substantiated commentary can be made on the validity of strategies like Merrick's (1958:5) "stopping practice", which, according to him, is aimed at mentally rehearsing the execution of what comes next in the music[18].

5.5 Mental practice

The idea of mental practice is not foreign to the field of piano playing. An avid supporter of mental practice as a method for advancing technical proficiency, is Jorge Bolet, who emphatically states (Noyle 1987:17) that he has

> ... never ... solved either a major mechanical problem or a musical problem at the keyboard. I practice so much at the keyboard and then I have had enough ... Whatever I do at the keyboard gives me enough practice material so that I can practice mentally, for twelve, fifteen, twenty hours, whenever I'm awake.

Bolton (1980:10) suggests that the learner, for a passage that he finds particularly difficult, should "... try thinking it without playing. Imagine the muscular sensations and the keyboard, and catch hold of the keys mentally only".

Mischa Dichter (Noyle 1987:53) also engages in mental practice, but only after the notes are learned, preferring "contact with the instrument" while the piece is still unfamiliar to him.

Ashkenazy, on the other hand, is not much in favour of the idea of mental practice (Noyle 1987:6), "... because I think you need the physical touch with a piano and your fingers have to mechanically find the right places. The mechanics also have some part, they have to be there."

Mental practice, which apparently can lead to considerable positive transfer in the performance of the actual task, can be described in rather more formal terms as "[a] practice method in which the performance on the task is imagined or visualized without overt physical practice" (Schmidt 1988b:422). Mental practice is thought to be mainly an opportunity to sort out the cognitive elements

[18]Bigler and Lloyd-Watts (1979) apparently advocate a similar strategy, which they refer to as "STOP-PRACTICE".

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of a task, for instance the sequence of events and the reviewing of previous experiences in order to avoid mistakes that may have occurred previously; thus it should occur mainly in the acquisition phase of learning (Schmidt 1988b:417-418). Apparently, learning of the actual *motor* skills does not benefit much from mental practice. Other explanations for the benefits of mental practice are that (Schmidt 1988b:418-9) additional practice is obtained due to the fact that

> ... motor programs for the movements are actually being run off during mental practice, but the learner simply turns down the "gain" of the program so that the contractions are hardly visible

or that the performer is merely preparing himself for the coming performance by setting his arousal level to an appropriate level.

Finally, some attention should be directed towards Coffman's (1988:1086-A) experimental study to establish the effects of type of practice - physical, mental, alternating physical/mental and practice under a "motivational control" - and aural knowledge of results (KR) on improving piano performance in novice pianists[19]. The performance parameters that were investigated were performance time duration, number of pitch errors, and number of rhythm errors. Results of the investigation showed that all three groups engaged in some sort of practice, displayed faster performance time than the control group, and that the physical and alternating physical/mental groups showed faster performance times than the mental practice group, but did not significantly differ from one another. From this Coffman (1988:1086-A) concluded that "... mental practice can effectively improve the novice pianists' performance speed, especially when alternated with physical practice".

5.6 Guidance

Guidance, i.e. "[a] series of techniques in which the behavior of the learner is limited or controlled by various means to prevent errors" (Schmidt 1988b:422) is applied simply by guiding the learner through the task that is to be learned. Although guidance is sometimes regarded as a performance variable rather than a learning variable, i.e. improving the performance under which guidance is given rather than effecting the relatively permanent changes associated with learning, Schmidt (1988b:420-421) notes that it is possible to make some generalizations about guidance as a useful tool in aiding learning. The first is that guidance is most effective in the early stages of learning, when it is more important to "get the task going" rather than to produce a refined response. Secondly, guidance appears to be most effective for slow rather than fast tasks; this observation places a question mark over the extent to which guidance procedures may be of use for piano technique, because difficult technical problems are usually problems that require rapid execution.

[19]While the present study is not aimed at piano-technical motor behaviour in children, these findings are nevertheless mentioned here for the sake of completeness.

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It is interesting to note that Ortmann (1981:96) advises against the teacher moving the learner's arm, hand or fingers through the movement patterns that are desired for efficient execution:

> The teacher supplies the force and makes the movement actively whereas the pupil makes it passively. As a result the muscles responsible for the movement do not contract ... Muscularly, the pupil has learned nothing. At most he has been given certain sensations of rotation at the joint at which movement takes place.

To render guidance effective, a force should be instead be introduced in a direction *opposite*, rather than parallel, to the direction of the required movement; "... if finger-drop be the problem, press up against the descending finger". While such an approach may seem rather unconventional, it does have a physiological foundation, namely that "... a muscular condition does not depend upon the position of the parts but upon the external resistance opposing the maintenance of the position".

5.7 Summary and conclusions

Experimentation in motor learning has been negligent with respect to the use of verbalized instruction to form a concept of the task just before practice. Apparently, verbalized instruction is generally of limited usefulness, because words are relatively crude descriptors of complex movement patterns; learners in any event can only remember a limited number of instructions. Observational learning with insight into the learner's knowledge of results seems to hold some promise for students of piano playing; the observational part is however hampered by the fact that many important dimensions of the movement are unavailable to the subject's view. The usefulness of a close-up filming of the fine muscle movements in a proficient piano performance remains to be investigated. It appears as if the use of verbal pretraining to isolate for special attention stimulus or display elements of the motor task, like the topography of the keyboard, could benefit the pianist when he is to perform the whole task later; more research is however necessary to confirm this presumption. The apparent belief among certain pianists that a rational, scientific approach to the problems of piano technique will adversely affect the aesthetic side, was shown to have been discredited by some of their colleagues. It appears as if knowledge of some principles from physics and physiology applied to piano playing could benefit the learning of piano-technical skills; again however, some more research is needed to verify this statement. The pianist should however beware of treatises misinterpreting these principles, which also have found their niche in the literature on piano technique. The validity of a Suzuki-type approach for establishing a prepractice reference of correctness in advanced piano playing, also warrants some further investigation.

The fact that performance deteriorates under massed practice conditions should not be undue cause for alarm, as the same does not necessarily apply to learning. Therefore, contrary what is commonly believed, the fatigue associated with massing does not necessarily cause people to learn ineffectively.

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The latter finding appears to be confirmed by the fact that certain pianists recommend long hours of massed practice at the keyboard. But it can also be stated that no single, optimal distribution of practice and rest periods exists; such a distribution would rather then depend on the nature of the task to be learned and certain capabilities of the learner himself, for instance his concentration ability. On the grounds of the rule-learning premise of schema theory, it seems justifiable to state that the practice of piano-technical skills would benefit from variability in the learning process. Which aspects should be varied is however not certain; a research effort aimed at clarifying this matter should be well worth the while for students of piano playing.

Brief explanations in terms of information-processing in the motor systems sense and schema theory, were offered to account for the fact that learning of motor skills in general, is more efficient under random practising conditions than under blocked practice, even though performance under the latter type of practice is better. More important, though, is the contradiction of the traditional notion - probably also held by the majority of pianists and teachers - that practice should always be structured so that performance is maximized during the practice session. Although some more research is required into the matter in general and with respect to piano playing in particular, it appears as if the traditional method of continuous repetition of a motor task until it is correct, is not the most effective way to practise; rather, a number of trials should be practised in a quasi-random order to achieve maximum learning.

Apparently, practice and concert conditions do not have to match in order to ensure a successful performance; from a motor systems viewpoint with its notion of internal states, it appears to be rather a question of cultivating in training, the underlying processes that are common to both acquisition and the concert performance situation. Unfortunately, researchers know very little at present about the nature of these processes.

While slow practice of fast passages is widely employed among pianists, research carried out on the perceptual nature of rhythm, indicated that different motor programs are required for executing the same passage at different speeds, implying that practising a fast pattern at a slower rate might be counterproductive. These findings also imply that transfer of a piece practised slowly, to a situation where execution at a high speed is required, is not as straightforward as suggested by Schmidt's use of the overall-duration parameter in the generalized motor programming situation. The significance of these findings is perhaps enhanced by the fact that some eminent piano pedagogues indeed discourage the habitual practising of fast passages at a slower rate. It was also pointed out that the former findings apply to the practising of fast passages in varied rhythmical patterns as well; as in the former case, arguments from the literature on piano playing, both for and against this method, were presented. The reasons why this form of practice apparently does not have any detrimental

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influences on the playing of certain accomplished pianists are certainly open to speculation, and thus deserves some further investigation; perhaps it does not have any influence at all, or for some hidden secondary reason, indeed enhances their technical facilities.

The view was pointed out that transfer between motor tasks is typically small, because different motor abilities come into play for different motor tasks. More research into this matter pertaining to piano technique is clearly needed. Another area worthy of research effort involves the similarity between motor tasks in piano playing, because it is known that the amount of transfer between motor tasks depends on the similarity between the tasks. Certain experiments from motor behaviour science, involving negative transfer, hint that practising in "rhythms" may transfer negatively to the undistorted and fluent execution of the relevant passage; once again, more research is needed in order to be able to make any conclusive recommendations.

It was shown that the literature on piano technique contains arguments both for and against practising parts of a piece in isolation. Motor programming theorists hold that practice of the part in isolation, may so change the motor programming of the part, that it is not the same any more as it is in the context of the whole. It appears as if serial skills can benefit more from practice of parts in isolation than continuous skills; it may thus be worthwhile to investigate the structuring of practice based on whether a particular piece displays predominantly serial or continuous skill characteristics.

Mental practice appears to be most effective when applied in interaction with some physical contact with the keyboard. Motor programming notions can be used to account for the benefits of mental practice; it appears to be possible to execute a motor program with a very low gain, resulting in muscular contractions that are hardly visible. Particularly interesting insights into the subject of guidance, however, apparently can not be inferred in this manner.

It has been shown above that explanations of a fairly wide variety of practice phenomena can be offered using concepts from the motor systems approach. The same apparently can not be said of the action approach, perhaps because research into that approach is only in its initial phases. Another explanation could be that action systems theory is not much concerned with the idea of learning through practice in the traditional sense, especially in view of the idea of practice without repetition mentioned earlier in this thesis. It would have been most interesting to watch a pianist like Abby Whiteside, whose teachings apparently display many action premises, practise; unfortunately, her monographs reveal too little in this regard. Clearly, the matter of practising under the action approach - as well as the matter of learning under this approach, as was pointed out earlier - requires some extensive research.

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