CHAPTER 4

THE ACTION SYSTEMS APPROACH TO MOTOR CONTROL AND LEARNING WITH SPECIAL REFERENCE TO PIANO TECHNIQUE

4.1 Introduction

Action can be described as "... goal-oriented motor behavior" (Adams 1987:66).

Reed (1988:46) defines *action systems theory*[1] as resembling

> ... 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.

Although the difference between *motor systems theory* - "... the 'classical' and 'established' one in the motor domain" (Van Wieringen 1988:88) - and *action systems theory* is not altogether clear, a broad concept of the difference between the two can be gathered from the following descriptions:

> Motor systems theories ... may be loosely described as information processing theories making use of constructs like 'programmes', 'schemata', 'memories', 'images' ... Action systems theories, on the other hand, dismiss the former approach as an incorrect application of the computer metaphor to biological organisms. Instead, the complementarity and reciprocity between the organism and its environment is drawn to the foreground, and attempts to explain behaviour do justice to this intimate and non-contingent relationship.

Action theorists, for example Reed (1982:98-99), reject the psychological dichotomy consisting of the peripheralist (closed-loop) versus centralist (motor programming or open-loop) theories of motor control. It has been pointed out earlier that some theorists, for example Schmidt (1988b) and MacKenzie (1988), hold that motor behaviour is probably best represented by a hybrid of the two

[1]For the sake of convenience, this definition (which was given in Section 1.3) is reproduced here again.

approaches. A major cause for this viewpoint is the fact that the closed-loop model is only satisfactory as far as relatively slow, highly accurate movements are concerned, while the centralist model is employed to account for fast motor responses. Reed (1982), however, points out that all such arguments, which at a superficial level have much to offer, are hampered by the common inconsistency that afference is assumed to be sensory feedback and efference assumed to be motor output from central control[2]; thus "... it would be better to make a clean break with these traditional but incorrect ideas and start over in conceptualizing action" (Reed 1982:107).

Closely associated with action systems theory is the *ecological* perspective to movement, which is depicted by Schmidt (1988b:16) as "... emphasizing the study of movement in natural environments, and the evolution of physical and biological constraints of movement". An ecological approach to music could be particularly appropriate on the grounds of the following statement by Clynes (1982:vii):[3]

> Music is one of man's most remarkable inventions - though possibly it may not be his invention at all: like his capacity for language his capacity for music may be a naturally evolved biologic function. All cultures and societies have music.

Schmidt (1988a:5) differentiates as follows between the newer *ecological psychology*[4] and the long-established field of *cognitive psychology*:

> ... cognitive psychology ... [has] made extensive use of internal representations, cognitive structures, and sometimes even anthropomorphic explanations of behaviour in an attempt to theorize about complex mental events ... . The neo-Gibsonians argue that this style of explanation does not provide an adequate answer, essentially because the nature of these representations ... themselves must be explained, which simply puts off the ultimate problem until some later time. Instead, this group has attempted to discover how much order and regularity one can have by assuming no representations (or, at most, minimal representations), using a number of fundamental organizing principles.[5,6]

The latter approach holds that representations of motor processes can always be added at a later stage, if required, instead of stating them beforehand, as some cognitive theorists seem to do.

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[2]Kerr (1982:305) describes *afferent pathways* as "the peripheral nerve pathways that bring sensory information into the brain via the spinal chord" and *efferent pathways* as "the peripheral nerve pathways by which motor responses are carried from the brain to the skeletal musculature".

[3]It is however not clear from the context whether Clynes intends his statement to include in particular the motor aspects of music as well.

[4]Schmidt (1988a:4) notes that the field of ecological psychology "... is very broad and comprehensive, attempting to deal in a consistent way with such diverse issues as perception, motor control, ecological and evolutionary perspectives, growth and development, and numerous other ... areas, only a small part of which is immediately relevant to motor control".

[5]The word *anthropomorphic* refers to having human form or human characteristics.

[6]It is possible to differentiate between two streams of thought in action systems theory, namely the Gibsonian and neo-Gibsonian schools (Van Wieringen 1988:87). The Gibsonians try to explain the motor behaviour as a function of information specifying the environment, while the neo-Gibsonians resort to physical principles guiding the behaviour of energy-consuming open biological systems.

The origins of action systems theory can be traced back to a desire to develop an ecologically based taxonomy of *all* movements - not just skills (Reed 1988:46);

> [i]t begins with the hypothesis that there are many *different* action systems, each evolved by natural selection to facilitate a unique behavioural function, and therefore each with its own principles of organization ...

Psychologists, physiologists and engineers have all tried to identify and single out basic movement units as a means to effect a better understanding of motor control. In action systems theory, however, these units "... are defined *ecologically*, not biomechanically, anatomically, or physically" (Reed 1988:47). Action theorists furthermore claim that the elementary units of action are themselves functional, and that "... bodily displacements are a consequence of, not constituents of, actions" (Reed 1988:46). Although Reed does not deny the existence - which can be proved by laboratory experiment - of neurobehavioural[7] units, he does not recognize "... the *theory* that functional actions must be constructed out of such purely mechanically specific units".

According to action systems theory, human action in broad terms is structured as follows from its subsidiary components (Reed 1988:47): at the highest level of analysis, the principal constructs are *action systems*, which are comprised of *action cycles*, each of which in turn consists of "... *postures* and *movements* relevant to the task of that system [italics added]". Usually, several action systems are functioning simultaneously, "... the competition and coordination among action systems giving rise to a number of *basic actions* in each system".

The concepts mentioned above, and their relationship to each other, will be discussed more extensively in Section 4.2. The action approach to motor learning - a subject on which relatively little information seems to be available - will be investigated in Section 4.3, followed by some general conclusions in Section 4.4, specific reference being made to the control and learning of motor skills pertaining to piano technique.

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[7]According to Lee (1984:143), quoted by Reed (1988:46), a neurobehavioural unit can be identified as follows: "... if a pattern remains coherent even when reorganization would be functionally useful, then one can infer that it is a basic neurobehavioral unit".

4.2 The action systems approach to motor control

4.2.1 Degrees of freedom as a common point of departure for the action and motor viewpoints

Before attempting to unravel some of the intricacies of the action approach to motor control, it is worthwhile to first of all explore some of the common grounds held with the motor systems approach discussed earlier.

In particular, Bernstein's (1984) conception of the motor system, which is considered by Schmidt (1988a:6) to be "... a cornerstone of the action view... and often of the motor view, it must be added...", deserves some attention. According to the view of Bernstein, the motor system is comprised of a great number of degrees of freedom which must somehow be controlled by the organism. Thus, movement can be studied at different levels of analysis depending on the number of degrees of freedom. Various possibilities exist in turn for determining the number of degrees of freedom, for example by

> ... counting the number of degrees of freedom in the particular joints (the elbow has one, the wrist two ...), by counting the number of muscles which act at the various joints ..., or even by considering the massive number of single motor units which must ultimately be organized in skilled actions (a given muscle may have several thousand motor units). (Schmidt 1988a:6)

In view of this approach to the motor system, Schmidt (1988a:6) identifies as the common goal for both motor and action theorists the

> ... search for ways that the various degrees of freedom are *constrained*, or coupled to one another, so that the control of a number of degrees of freedom is handled as a single unit, itself with only one degree of freedom.

While motor theorists use the motor programming idea for this purpose, the action systems view utilizes the concept of a *synergy*, or *coordinative structure*, which can be defined (Schmidt 1988a:6) as "... a group of muscles and joints acting together as a unit". Although Schmidt (1988a:6) states that he is not sure whether "... at a behavioural level of analysis, one can meaningfully distinguish between coordinative structures and motor programmes", at the level of neural control action theorists emphatically deny the existence of motor programs for constraining the various degrees of freedom.[8]

[8] As was pointed out in Section 2.9.

4.2.2 Actions vs. movements

Fundamental to Reed's (1982,1988) thesis on action systems theory lies the conceptual distinction between *actions* and *movements*.

According to Reed (1988:48), *actions* can, due to their goal-directedness, be categorized either functionally, or in terms of their interaction with the environment. *Movements*, on the other hand, are traditionally categorized along the following widely accepted lines:

1. *Kinematically*, that is in terms of displacement of the limbs and torso seen with respect to some arbitrary point of reference.[9]
2. *Kinesiologically*, "... as displacements with respect to standardized anatomical axis (e.g., flexion-extension, pronation-supination ...)".
3. *Dynamically*, i.e. in terms of the forces that are responsible for the displacements.

Movements can, however, *not* be defined functionally or environmentally due to the fact that any one movement may be a subsidiary constituent part to many different actions.

While convention thus holds that movements are limb displacements of some sort and that movement control, therefore, is control of the "... coordinates of the body in space and time" (Reed 1988:48), Reed's (1988:51) fundamental hypothesis is that "... an action is made up of whatever displacements suffice to realize the agent's goal. What matters is not the displacements in space-time, but the movements and postures in the environment". Phrased alternatively, Reed (1988:49) proposes that

> ... animals and people achieve their goals not by moving their muscles, nor even by displacing their limbs and bodies, but by coordinating a series of subsidiary actions. Any action is therefore seen as made up not of mechanically specific displacements, but of functionally specific components *which themselves would count as actions.*

Two classes of functionally specific components of action are identified by Reed (1988:49), namely

- postures
- movements[10]

These components will be examined more closely in the following sections.

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[9]This method of description was pointed out in Section 2.2.1.

[10]Reed's notion of movement in the context of action should not be confused with movement in the "traditional" sense described earlier in this section and in Chapter 2.

4.2.2.1 Postures

Postures should be regarded as the orientation components of an action, having to do with the actor's attempt to maintain a relatively persistent orientation of himself and his perceptual systems to the environment, the ultimate balancing act for humans being "... to maintain an upright posture while breathing, which changes the shape of the chest and disbalances the trunk above the hips and the head above the trunk" (Reed 1988:60-61). Thus, "[a] posture is an action in its own right, a persistent achievement of an organism in the environment" (Reed 1988:52). The action of maintaining an upright posture is *functionally* defined by Reed (1988:61) as "... any set of displacements of the musculo-skeletal system that serves to keep the head orientated to the environment above the neck and trunk [italics omitted]". Displacements in space - or the lack thereof - can not be used to (uniquely) define the upright stance, simply because "... *any* such displacements will do, so long as the above functional requirement is met".

4.2.2.2 Movements

Movements can be considered as subsidiary actions representing changes in the orientation components of higher level actions. In particular, movements are "... specific changes in posture that are organized by agents while effecting particular changes in the relation between the organism and the environment" (Reed 1988:52). The action understanding of movement is perhaps best illustrated through Reed's (1988:49-51) description of a baseball player engaged in the motor task of catching a ball:

> This act is not made up of some fixed sequence of displacements (these would vary indefinitely, depending on the ball's trajectory, the player's initial position, state of alertness, and so on). Rather, a successful catch involves orienting oneself to gravity, the playing field, and the course of play, orienting one's perceptual systems to the opposing hitters and the ball's motion ... and changing one's orientation so as to meet the ball with one's glove. The well prepared player can thus catch a ball without *any* displacement of the hands whatsoever, if the batter hits a line drive to the expected spot - yet surely this non-displacement would count as a highly skilled action!

On noting that postures can be defined functionally in an environmental sense, it follows that movements should be *functionally nested* changes of posture (Reed 1988:61) - "... in addition to serving its own function (whatever that might be) a movement must not be disfunctional with respect to ongoing postures". Thus, riding a bicycle should not interfere with the function of maintaining a stable head and unrestricted visual facilities; in humans speech does not interfere with the respiratory functions. Postural precedence effects[11], i.e. postural adjustments to amend for movements, are

[11]This subject will be subjected to further scrutiny in Section 4.2.3.

regarded by Reed (1988:62) as a means for the "... *maintenance* of postural *function* (which may or may not be directly related to balance) before, during, and after the movement", rather than a way to account for the disbalancing effects of the movement. Thus, postural precedence effects may be seen as "... evidence of neural mechanisms for *inserting movements into postural cycles*".

4.2.2.3 Posture as the principal catalyst in piano technique: the method of Taylor

Taylor (1979) proposed an approach to piano playing, based on the principles of the music educator Raymond Thiberge and the teacher F. Matthias Alexander, that advocates postural control as the main catalyst for all aspects of piano playing; in postural control, "... Taylor believes he has found the Gestalt that harmonizes all the separate motions and positions of piano playing into one simple, coordinated act" (Bridges 1985:53-54).

The benefits that the mastering of Taylor's approach apparently holds for the advanced pianist seem to be staggering[12]; proficiency in the application of his principles would imply that "[i]f we can play a work at sight, then we have no need to practise it" (Taylor 1979:72). It is interesting to compare comments made or implied with respect to the difficulty of Chopin's *Etude* Op. 10 No. 2 by established concert pianists on the one hand, and Taylor on the other hand. Thus Ian Hobson (Elder 1984:19) notes that this particular *Etude* "[i]n a way ... is the most difficult of all the [Chopin] etudes", and Peter Orth (Elder 1979:21) states that

> [y]ou have to examine every tie, eighth note ... You can't slough over things. For example, these thumb notes are here for a reason: they balance the other side of the hand. If you don't play them out, the piece doesn't do the hand much good.

Taylor (1979:78), however, declares that

> [t]his is one of the easiest concert studies in the repertoire; if it doesn't 'play itself' at the first reading, this is salutary proof that the necessary conditions of co-ordination [established by correct postural control] are missing.

(It is of course assumed that a proper mental conception of the piece has been established beforehand, i.e. the performer knows the notes, expressive indications, *et cetera*.)

Like Reed, Taylor (1979:22) apparently sees more to posture than meets the eye:

> (i) [p]osture includes not only 'position', but also the way in which the parts are maintained in position; (ii) [t]he human body is an indivisible entity, in which the behaviour of any single part is dependent on the relationship existing between all the parts.

Thus the inevitable result of a postural deficiency, which could manifest itself in for instance a stiff

[12]Thus its inclusion in the present discussions.

neck, is "... a reduction in one's capacity for co-ordination"[13] (Taylor 1979:23).

According to Taylor (1979:27), two basic, mutually exclusive, postural conditions exist, namely *expansion* and *contraction*. Taylor states that these conditions should actually be referred to by using the grammatical forms *contracting* and *expanding*, because of their dynamic (i.e. ongoing) nature; for purposes of description it is however convenient to assume that they are static. According to Taylor (1979:63), the "liberation of talent" is closely related to the improvement of posture, and the substitution of contracting postures by expanding ones.

The *expanding* posture[14], which serves to enhance coordination, causes

> ... the tendency ... to become longer and wider, as the joint surfaces separate away from each other. The head is well balanced on the neck, whose muscles are in minimum tension, the shoulders are loose and wide in relation to the back so that the arms tend to hang towards the front of the body, and there is no pronounced hollow in the small of the back caused by hypertension in the muscles of the dorsal vertebrae. (Taylor 1979:29)

Taylor even goes so far as to suggest that, "[w]ithout exception", the great instrumental and vocal performers[15] have in common the expanding posture. Bridges (1985:56) describes how he has observed from film material the way the pianist Arthur Rubinstein apparently applies the expanding posture:

> With each important technical gesture, a loud chord or an octave scale, Rubinstein moves his head "forward and up" and visibly lengthens his spine with the shoulders loose and dropped all the while.[16]

What makes this observation the more relevant is Schnabel's *verbatim* expression (Wolff 1972:24-25) of his view of piano playing as a form of musical speech:

> 'One speaks upward and forward', he said, 'and therefore one must not play downward and backward'.[17]

The *contracting* posture, on the other hand, which usually inhibits coordination, manifests itself in that a person tends to become (Taylor 1979:27) "... shorter and narrower, because the joint surfaces are drawn towards each other by opposing muscular tensions". Extreme consequences of the contracting posture could be neck tensions, rigid, pulled-back shoulders, prominent shoulder

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[13]Some of Taylor's views on coordination have been discussed in Section 2.8.5.1.

[14]Taylor (1979:64 ff.) supplies some guidelines of how the student of piano playing, by invariably using some guidance from a qualified teacher, can establish the expanding posture at the keyboard.

[15]Some of the great composer-pianists also seem to have advocated the expanding posture. Taylor (1979:75) quotes Chopin's statement that his *Etude* Op. 10 No. 1 was intended to widen the spread of the hand; which is, as Taylor interprets it, "... a natural result of the elimination of contracting tendencies".

[16]Bridges does however not neglect to mention at the same time that many pianists apparently do *not* exhibit the characteristics of the expanding posture, citing as an example the pianist Walter Gieseking.

[17]Schnabel did however not impose his way of playing on students who managed musical and technical control in a different manner (Wolff 1972:25).

blades and "... a pronounced hollow in the small of the back" (Taylor 1979:28). Taylor (1979:27-28) proposes a simple but effective - and rather startling - experiment which can be used as a diagnostic tool for determining whether a person is indeed the unfortunate possessor of a contracting posture:

> Stand facing a wall at such a distance that when the arm is held out horizontally, with the palm of the hand facing the floor, the finger tips are just touching the wall. Flex the arm quickly at the elbow, bringing the back of the hand up to the shoulder, hold it firmly in this position for a moment, then return the arm to the horizontal position. If you have contracting tendencies, you will find that the fingers no longer touch the wall, the arm seeming to have shortened by as much as an inch or two. Imagine this condition existing throughout the entire body in a greater or lesser degree - such is the contracting posture.

The reason for the shortening of the arm, or all the joint surfaces involved being drawn closer with respect to each other, is that the extensors of the forearm do not relax at the same rate as that of the flexors contracting when the arm is bent at the elbow, thus resulting in the simultaneous contraction of opposing muscles. The same is found with respect to the muscles of the neck and shoulder, because the arm cannot shorten without involuntary contraction of these muscles, illustrating the fact that "[t]here is no such thing as purely localised muscular activity" (Taylor 1979:29).

If the hand is simply brought into playing position at the keyboard under the expanding postural condition, the result will be freedom in mobility at the elbow before playing commences - which will not be the case under the contracting condition, although the playing positions achieved via both means may appear the same. According to Taylor (1979:31-32), to perform under the expanding posture is like being a detached observer watching the playing apparatus executing the appropriate actions; this state is preferred over a state in which each movement is concentrated on individually. Suppleness is maintained in the fingers by actually relieving the fingers from their role as the main functionaries in piano playing (Taylor 1979:58):

> To preserve maximum suppleness in the fingers, on which co-ordination with the keyboard depends, we must remove from them the burden of being treated as active agents in the act of tone production and instead regard them solely as transmitters of our basic gesture of expansion.

Apparently, learning to establish the expanding posture is a slow and painstaking process requiring considerable perseverance; from Taylor's (1979:63-73) description it seems unlikely that a student would be able to manage without the guidance of a qualified teacher. Furthermore, feedback about the correct posture appears to be quite alien to the normal modes of KR and KP employed in the piano playing lesson, as can be deduced from the following "... anatomically implausible, but empirically valid" description of the expanding posture by Thiberge (Taylor 1979:63):

> ... once the segments of the bone structure ... [are] correctly organised, a pressure initiated by "a subtle gesture of leverage against the thigh" ... [can] be transmitted through them to the fingertips without any intervening contractions.

Taylor's approach still needs to be tested scientifically in almost all areas to determine *inter alia* whether it is really the expanding posture which causes improved coordination, and if the improvements induced by it are potentially equally dramatic for all students.

4.2.3 Postural precedence effects

When a person voluntarily moves a limb, this movement is preceded by *postural precedence effects*, i.e. muscular adjustments to preserve the balance of the body.

According to Reed (1988:52), the insufficiencies of traditional motor control theories are pre-eminently exposed when required to explain

> ... the phenomenon of so-called postural 'compensation' for movement. The attempt to treat human movements as displacements caused by mechanisms of reflex, or centrally programmed, responses leads to a whole series of puzzles concerning how the nervous system balances and coordinates the body during active movement.

Reed (1988:72-73) subsequently points out that any of the several action cycles that comprise a common everyday task like eating would require postural adjustment prior to movement; examples are

> [e]xtending the head forward [which] tends to open the jaw ...; lifting the arms [which] may cause body sway ...; head rotation and arm movements [which] are interrelated ...; and breathing and balancing [which] are coordinately interphased.

Employing the motor systems approach to describe these skills would simply become a practical impossibility:

> In addition to having to postulate an immensely complex network of motor programmes, reflexes, and sensorimotor feedback circuits, all somehow adapted to each other by cognitive and motivational mechanisms, one also has to postulate an interconnected series of postural adjustments which are also adaptively coordinated (Reed 1988:73)

which leads Reed to conclude that "[t]raditional motor control research and theory, developed to explain the displacements of single limbs in space, is simply irrelevant to the movements and postures of actors in the environment".

Reed (1988:54) states that classical motor control theory has held that postural precedence adjustments are based on feedback about disturbances in balance. In particular, it has been believed that disruptions in balance, whether caused either by unexpected events in the environment or voluntary movements, are corrected automatically through mechanisms activated by sensory feedback.

Reed (1988:54), however, contends that there are two main reasons, supported by experimental evidence, why precedence effects can not be regarded as "reflexive, or as low-level closed loop sensorimotor mechanisms". The first is that

> ... postural precedence effects do not occur in specific muscles, or even in specific anatomical linkages, but in functionally specific regions. ... [T]he postural activities are organized in body

> regions (which may be anatomically quite diverse) that provide support ...

According to the second reason it is maintained that

> ... in a reaction time paradigm, where subjects can respond or not respond to a signal, one can show evidence of postural preparation prior to *non-movements* ... on those trials where no response is called for.

At the present time, it is generally believed among motor theorists that postural precedence effects are controlled by a combination of feedback and preprogramming[18] - according to Reed (1988:55), it is important to note "... the tacit assumption [that] if a movement is not reflexive, or sensorimotor feedback based, then it must be centrally driven or programmed".[19] Unfortunately, Reed (1988:58) does not get so far as to actually present the "... novel and useful reinterpretation of these phenomena" that is possible in terms of action systems theory.

While the questions around postural precedence effects appear to be of considerable theoretical significance for exposing the limitations of motor systems theory, it is not clear how explaining postural precedence in a functional manner will benefit learning of piano-technical skills. A question can nevertheless be identified with respect to postural precedence and piano playing, which will be stated here briefly. It simply concerns whether the postural adjustments required for maintaining a seated posture at the piano - which could vary among individuals from hunching over the keyboard to leaning backward so that the arms tend to approximate straight lines - have any influence on motor activities of the fingers, hands and arms involved in playing. If Taylor's notions on posture discussed in Section 4.2.2.3 are correct, it would intuitively be suspected that precedence effects indeed do influence coordination at the keyboard. Unfortunately, however, this matter will remain obscured in uncertainty until addressed through a proper scientific research effort.

4.2.4 Action systems and action cycles

Any coherent act is constituted of various contributing *action systems*[20], which on their part are comprised of characteristic *action cycles*. Reed (1988:65,67) considers all action cycles in humans to be "... rooted ... in the diurnal cycle and, to a lesser degree, in the seasonal cycles".

In traditional motor systems theory the notion that movement patterns are run off by motor

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[18]Neurophysiological experiments are cited by Reed (1988:55) which have lead traditional motor control theorists to come to the aforementioned conclusion. An account of these experiments is not included here in view of the behavioural level of analysis of the present study.

[19]This dichotomy was referred to earlier in Section 4.1.

[20]The human action systems and basic actions - the particulars which are not of immediate interest for the present study - are listed by Reed (1988:66).

programs implicitly attempts an explanation of *how* these actions occur. The claim that actions are constructed from postures and movements, however, is in itself not explanatory of how actions takes place. While the mystery thus remains on how movements and postures are functionally organized (Reed 1988:64), "[e]ven if we knew all the processes underlying postures and movements, which we do not, and even if we knew all the rules for the perceptual guidance of action - which we also do not [know]", action systems theory is presumed to be correct in stating that a human being is at any time involved in a variety of functional activities which overlap on a continuous basis. This can be inferred from the fact that

> [t]he basic orienting system, the appetitive and investigatory systems are operating continuously in the waking state and, very likely, also operate (in a much reduced fashion) during sleep. Locomotion, manipulation, speech, and play break up the day in varying clusters of activity as ... does eating. In humans, expressive activity only desists during sleep - and then not completely. Our faces are continually modulating their expressions as we engage in one activity or another. (Reed 1988:67)

According to Reed (1988:67), therefore,

> ... the problem of explaining the organization of action becomes one of explaining how these various streams of activity are *nested* into unified acts. And, where agents are capable of accomplishing more than one thing at one time, how the streams are kept *separately* nested, cycling in parallel.

Unfortunately, research into these problems at present is not even in the initial stages of gaining momentum;

> ... as yet we know very little about the action cycles of even a single action system, and there have been no studies whatsoever devoted to the rules by which people nest several action cycles into functional basic acts. (Reed 1988:73)

Reed (1988:68) proposes that the first step in a study of action should be to discover the range of variation of an action in order to determine which systems are nested into a functional coherent act. Once this range of variation is known, it can be controlled for experimental purposes. In pouring, for example, one would take under consideration the manner in which test subjects hold on to the cup, or the sequence in which subjects adjust the relevant objects before pouring begins - keeping in mind always that "... what ... subjects do vary are not responses, but functionally meaningful units of the pouring action: postures and movements, ecologically considered".

4.2.5 Basic actions

Reed (1988:68) defines *basic actions* as

> ... the most important nesting of postures and movements under a particular set of evolved environmental constraints, and as such they constitute the repertory of human daily skills. ... [B]asic acts are *not* 'innate' in the sense of genetically inherited patterns of movement; nor are they simply learned due to environmental constraints. They are *ecological* facts about the human *species*, not genetic or behavioural facts about individuals.

While owing its origins to the species, basic actions may however be further developed in the individual (Reed 1988:47). A representative example of an ecological fact particular to humans is the fact that people of all cultures eat with their hands; given the human anatomy and the human's ecological situation, the probability that the hands will be used for eating is so great, that it is not necessary to have this characteristic trait determined genetically (Reed 1988:69). Thus, in an infant,

> ... there need be no genetic programme for a 'bringing to the mouth' movement nor need there be some kind of reinforcement of reaching responses for hand-feeding to develop. What is needed are functional perceptual and action systems in the baby, and enough interest and motivation to begin to act.

At this stage, the definition of a basic act may be refined as follows (Reed 1988:69):

> What makes a basic act a definite entity is not a stereotype of configuration, but a *definite range of variation* which has been established by natural selection and within which most individuals of a species stay most of the time.

A simple example is that of human walking: people usually walk by using both feet; it is however possible to move along by hopping on one leg, for instance for the purpose of engaging in play.

Reed (1988:69-70) does not feel that consideration of rather obvious basic acts such as standing or walking are trivial or superfluous:

> We have concentrated so much on ascertaining the facts about the alleged mechanisms underlying certain simplified movements under conditions that are quite subtle and unrepresentative of daily life that we do *not* know, in anything like a scientific way, what the skills of everyday living are.

Subsequently, Reed (1988:70) comes to the rather startling conclusion that

> [w]e certainly do not know how to characterize the movements and postures involved in many of the most fundamental human bodily skills, nor are we well informed about what constitutes the normal range of variation of those movements and postures.

4.2.6 Tool use with specific reference to the hand

Action systems theory holds that (Reed 1988:75) "... tool use evolved out of ways of enhancing the basic acts of our human action systems". Humans use tools to extend their capacity for perception and action: "[o]ne can feel as well as *poke* with a stick. Note that one does not feel the stick, but through the mediation of the stick one feels some other object" (Reed 1988:74). The principle of interest here, which has not been explained yet, is that "... awareness of the tool becomes secondary to the awareness of what we are acting upon with the tool ...". In a different sense, this statement holds for piano playing as well: in performance, the accomplished pianist will be more aware of the sound picture than the keys that are depressed on the keyboard, which can here be regarded as the "tool".

According to Reed (1988:75), traditional motor control theories cannot be used to explain tool use. The irony is, however, that tool use skills are fundamental to the bulk of experiments from which these theories are inferred or by which they are substantiated. Typical tool use in such experiments would for instance involve the control of levers and joysticks, and the pushing of buttons in response to signals. Schmidt's (1988b:62) explanation of the functioning of the *pursuit rotor* used in tracking experiments is cited here to illustrate how complicated tool use in the laboratory can get:

> [A pursuit rotor has]... a target (usually a small circle) that is embedded in the surface of a turntable-like structure, and it rotates at a speed of 40 to 80 RPM. The subject holds a stylus in the preferred hand and attempts to keep its tip in contact with the target as it rotates.

A study of tool use should have some considerable advantages for piano playing. This is due to the fact that a tool, except for being an object serving as extension to the body, can also be considered "... an object inserted into an action cycle" (Reed 1988:75). The hand has from earliest times served as a tool for *inter alia* digging, grasping and kneading. Reed (1988:76) points out the fact that in neither of these cases the actions are defined by movement patterns: "... all of [these actions] can in fact be realized by a multiplicity of movement patterns. For example, one can grasp a tube as easily horizontally as vertically ...".

Some of the strongest indications in the literature on piano technique of an approach in which the hand is considered as a tool are found in the instructions and advice given on octave playing.

Neuhaus (1973:124) declares that correct use of the hand as an octave-playing tool causes

> ... a certain strong "hoop" or "semi-circle" from the tip of the little finger across the palm to the tip of the thumb, the wrist being maintained *absolutely essentially* [sic] in a dome-shaped position lower than the palm. This is far from easy for small hands and not at all difficult for large hands.

He stresses that for small-handed students the wrist should be held lower than the palm, all support being concentrated in the semi-circle and not in a raised wrist (Neuhaus 1973:125). It is furthermore possible to use this tool in four ways: octaves can be executed with the main distribution of activity in the fingers only, with the wrist only, from the elbow with the forearm only, and in passages requiring considerable volume "... with the whole arm, which from fingertip to shoulder joint forms a strong, resilient but unbending pivot ... excluding all movement of finger, wrist and elbow joint ..." (Neuhaus 1973:126). Slenczynska (1974:38) reports on making the hand

> ... into a stiff "octave mold" ...; the middle fingers [are] curled under so that they will be out of the way.

Whiteside (1961:53) adds some effective imagery in stating that for octave playing at high speed and volume, although the entire body is involved, it is the movement at the wrist that stands out as the "... crack of the whip"; similar imagery is used by Fleisher (Montparker 1986:11).

Suggestions of a "tool-like" application of the playing apparatus to issues of piano technique other than octave playing are also fairly common. Fleisher (Montparker 1986:11) states that the pianist's movements can be divided into two classes according to the nature and composition of the human body: "the upper arms for details, and ... the main corpus, the trunk, which takes care of the loose and supple movement, but should remain basically still". Neuhaus (1973:94) notes that in producing great volumes of sound, the fingers relinquish their roles as independently active units to become "... pillars, or rather arches under the dome of the hand" being able to bear the weight of the body. Evenness in playing can be obtained by

> ... ensuring that the arm, quiet, loose and practically motionless, is supported by the fingers acting as props: with such playing the knuckles are naturally raised ... . The arc formed by the finger from its point of support on the key to its beginning on the hand, supports, just like in architecture, the ... natural free weight of the arm. (Neuhaus 1973:118)

Whiteside (1969:39-40) states that the wrist should be considered a joint for transmitting action rather than for producing positive action, in that it allows the up-and-down action of the forearm to "flip" the hand into the required position with respect to the keys.

This section is concluded with Reed's (1988:73) statement that "[i]t is ... a real indictment of psychology that the analysis of tool use is still in a most rudimentary stage". It can only be hoped that this state of affairs will change for the better, as piano technique could benefit considerably from scientific knowledge of its particular use of the hand as a tool.

4.2.7 The dynamical systems approach[21]

The dynamical systems approach to motor behaviour entails that human limb movements are considered to be analogous to systems of levers and masses, swinging around joints under the influence of forces like gravity. Active muscle, in particular, can be modeled as a spring with non-linear characteristics which

> ... shows systematically increased tension as the length (stretch) is increased, but with some falling-off of tension with extreme lengths. To a first approximation, the muscle acts like a 'complicated spring', in that the tension developed at a given level of activation is a function of its length... (Schmidt 1988a:9)

Thus many movement characteristics, for instance "... maximum velocity, the position at which maximum velocity is reached, the time to peak acceleration ..." (Schmidt 1988a:10) can be explained in terms of a dynamical system model, or interlinked systems consisting of masses and springs.

The event of the dynamical systems approach has given rise to the question (Schmidt 1988b:262)

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[21]*Dynamics* is "a branch of mechanics [in physics and applied mathematics] that deals with forces and their relation to the motion of bodies" (The Penguin English dictionary 1985:258).

of

> ... why it is necessary to invent elaborate central codes and representations to account for the regularity we see in human movements, when so much of this regularity can be had "for free" by considering the dynamic properties of the moving limb-muscle system.

Motor systems theorists, for instance Schmidt (1988b:264), values the dynamical systems approach as a way to simplify motor programming theories of movement, as was pointed out in Section 2.8.6:

> [b]y considering the well-known property of muscle to behave like a "complicated spring" and by designing a motor program to *exploit* this feature of the motor apparatus, a complex trajectory can be achieved with a minimum of complexity in the program itself.

The fact that action theorists view the matter rather more radically, is acknowledged by Schmidt (1988a:9):

> The goal [pursued by action theorists] has been to account for *all* of the order and regularity found in skilled limb control (and speech) via such [dynamical] processes, rather than to postulate that any of the order and regularity was embodied in the CNS in the form of central prescriptions (or motor programmes) for the actions. [Italics added]

The problem of infinite regress has been referred to previously as one of the main action viewpoint criticisms against the motor programming notion. Schmidt (1988a:16), however, points out that the same problem is present in some of the action dynamical models of limb trajectories. It is not known how the coefficients for the terms in the differential equation[22] describing the movement is set up or pre-determined, or, in general,

> ... how *this* particular organization is set up, how it is realized physiologically, and how the system 'knows' that this is the organization which will accomplish this task ... And, because this organization will have to be changed to accomplish some other task ... from where does this *alternative* organization arise?

Another concern raised by Schmidt (1988a:16) is the fact that

> ... such modelling efforts involve a search for mathematical *descriptions* which will account for the observed data. As such, it is unlikely that the model chosen (a) will be the *only* model capable of accounting for the data or, as a result, (b) will tell us in any strong way about the underlying mechanisms.

Schmidt (1988a:17) finally points out that some of the differential equation models that can be employed to describe the experimental data are essentially "... the kinds of ideas specified by the motor programming viewpoints".

It is once again not clear how the advantages of a dynamical approach to movement would be applied to the complex activities involved in piano playing, as dynamical systems paradigms apparently have not yet been designed to address small-muscle movements as finely refined as those associated with piano technique. One would nevertheless presume intuitively that certain oscillatory

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[22]Because of its mathematically involved nature, this topic is not dealt with here more fully. Some explanatory notes are however given by Schmidt (1988a:15).

movements, concerned mainly with larger parts of the playing apparatus, which appear to be "self-sustaining" once the right "feeling" has been established, for instance the execution of octave tremolos (as referred to in Section 3.2.1.2), are ideal candidates for description by means of a dynamical systems differential equation. From a theoretical point of view, in any event, it is important to be aware of the existence of this approach, especially in view of its arguments on the invalidity of the notion of central control.

4.2.8 The action approach to information assimilation

In the action systems approach, as opposed to the motor approach, an important area of focus is the way in which the organism interacts with information from the environment;

> ... the older views ... either did not involve environmental information at all, or ... viewed its reception by the organism as passive, with information processing activities then later used to decode it (or make sense of it). (Schmidt 1988a:11)

In contrast to the traditional viewpoint, "[e]cological views regard information pickup as *direct* ... not requiring elaborate information processing to detect its implications for action".

Control of the process of nesting movements into postures requires perceptual information. Orientation of body members with respect to another is, according to Reed (1988:63) "... a purely propriospecific function. The hand can be related to the trunk, and the trunk can be related to the head, regardless of how any of them are oriented to the ground". However, for these inter-orientational relationships of body members to be functional, "... a coordinate ability to orient one's whole self to the direction of gravity, the path of locomotion, obstacles on the ground ..." is required; this ability is based on what is termed *expropriospecific* information, or information specifying one's position with respect to the environment. Human beings' main source of expropriospecific information is vision.

In order to conduct the present discussions on information pickup from the environment in an organized manner, it is first of all necessary to clarify the relevant terminology, which *inter alia* includes terms like sensation and perception. This will be followed by a discussion on Gibson's notion of the senses as perceptual systems.

4.2.8.1 Sensation, perception and proprioception

Gibson (1966:1) points out that the verb *to sense* has two distinct meanings; "... first, to *detect something*, and second, *to have a sensation*". The related term *to perceive* also has two meanings, namely "to understand, realize" and "to become aware of through the senses" (The Penguin English dictionary 1985:604).

Some remarks are in order here for further clarification of these terms. When the senses are used to perceive in the sense (*sic*) of the second meaning of the word, the first meaning of the term *to sense* is valid, i.e. the relevant connotation is that involving *detection* by the senses. The second function of the senses, namely endowing humans with sensations, is by no means the same as those facilities of the senses that enable them to perceive. Thus Gibson (1966:2) regards it necessary to

> ... distinguish the input to the nervous system that evoke conscious sensation from the input that evokes perception ... The detecting of stimulus information without any awareness of what sense organ has been excited, or of the quality of the receptor, can be described as "sensationless perception". But this does not mean that perception can occur without stimulation of receptors; it only means that organs of perception are sometimes stimulated in such a way that they are not specified in consciousness.

Thus it can be said, in an apparently paradoxical manner, that perception is not based on sensation, where sensation refers to having sensations. But perception is always based on sensation as the detection of information. The distinction between sensing in *sense perception* and sensing in *having sensations* is further elucidated by Gibson (1966:58) as follows:

> The former is sensitivity to information while the latter is sensitivity to something else - energy, or the receptors excited by energy, or the nervous pathways transmitting the excitation by energy, but in any event a kind of sensitivity to be considered separately.

It seems appropriate here, while clarifying terminology pertaining to human information gathering from the environment, to explain in greater detail what is meant by the concept of a *stimulus*. In the sense it is normally used in psychology, the term stimulus signifies "... an object of some sort that is *presented* to or *applied to* an individual, rat or human, in a psychological experiment", any stimulus usually being applied as light (colour), sound, or odour (Gibson 1966:28). Gibson, however, emphatically points out that a distinction should be made between the *source* of a stimulus and the stimulus itself; "[t]he former are objects, events, surfaces, places, substances, pictures, and other animals. The latter are *patterns and transformations of energy at receptors*." It is also necessary to distinguish between an available stimulus and an effective one, the latter quality being dependent on *inter alia* the presence of an observer and the state of his receptors.[23]

It has been pointed out earlier in the present study[24] that the difference between perception and proprioception lies in the fact that the former has to do with the environment, while the latter applies to the body. According to Gibson (1966:44), it is furthermore necessary to discriminate between imposed stimuli, which is forced on a passive organism, and obtained stimulation, which is caused

[23]In the literature on piano playing, the idea of an internal stimulus is acknowledged as well; Kochevitsky (1967:31), for example, identifies as an auditory stimulus "the inwardly heard tone".

[24]In Section 1.3.

by activity - implying that it is necessary to consider the following four categories for the reception of stimuli:

- imposed perception
- imposed proprioception
- obtained perception
- obtained proprioception

Imposed perception, or exteroception in the classical sense of the word, is the kind of perception generally studied by psychologists and physiologists. It "... arises from the skin, nose, mouth, ears, or eyes when these organs are passive and the stimulation impinges on them, or is applied to them" (Gibson 1966:44). *Imposed proprioception* occurs when the limbs of the passive individual are moved without any participating effort on the part of the individual (Gibson 1966:44-45). *Obtained perception* is described by Gibson (1966:45) as "... [arising] from the classical sense organs when they are oriented to the environment by way of the body and when they are active, that is, when they adjust and explore so as to obtain information." Finally, *obtained proprioception* occurs when the individual executes performance tasks requiring voluntary control. Proprioceptive systems overlap with the perceptual systems, but do not correspond with them; thus smelling and tasting are not regarded as proprioceptive, or muscle sensitivity as perceptive (Gibson 1966:45).

4.2.8.2 Perceptual systems

In Chapter 2 considerable interest has been focused on the theoretical approach involving human beings as processors of information. Models were proposed for the way information is picked up by the senses from the environment and subsequently processed through various stages to lead in the final instance to some sort of motor response.

Gibson (1966) does not regard the different senses as mere passive receptors of stimuli or producers of visual, auditory, kinesthetic or other sensations, but rather thinks of them as interrelated perceptual systems, or, as Carmichael puts it, "... active seeking mechanisms for looking, listening, touching, and the like" (Gibson 1966:v); he also holds that "... the perception of reality is not something assembled or computed by the brain from an ever-varying kaleidoscope of sensations". The senses therefore, when considered as perceptual systems, can obtain information about the environment without the intervention of an intellectual process (Gibson 1966:2). Gibson (1966:5) sums up the essence of his understanding of the capabilities of humans and animals *to sense* as follows:

> ... the input of the sensory nerves is not the basis of perception as we have been taught for centuries, but only the basis for passive sense impressions. These are not the data of perception, not the raw material out of which perception is fashioned by the brain. The active

> senses cannot simply be the initiators of *signals* in nerve fibres or *messages* to the brain; instead they are analogous to tentacles and feelers. And the function of the brain when looped with its perceptual organs is not to decode signals, nor to interpret messages, nor to accept images. These old analogies no longer apply. The function of the brain is not even to *organize* the sensory input or to *process* the data ...

Carmichael (Gibson 1966:v) notes that the vast amount of sensory experiences, identified and studied in laboratory experiments in the fields of psychology and physiology, involving passive stimulation of rigorously controlled receptor organs, are treated by Gibson as "... by-products of perception rather than building blocks". It is pointed out by Gibson (1966:6) that efforts aimed at a better understanding of the perceptual facilities should not be directed at the neurophysiological level of analysis:

> Since the senses are being considered as perceptual systems, the question is not how the receptors work, or how the nerve cells work, or where the impulses go, but how the system work as a whole. We are interested in the useful senses, the organs by which an organism can take account of its environment and cope with objective facts.

Gibson (1966:47 ff.) identifies and describes five perceptual systems which are not mutually exclusive, but often focus on the same information; the same information can be assimilated by a number of perceptual systems acting together, as well as by one perceptual system working on its own (Gibson 1966:4). The perceptual systems are classified by modes of activity and not by modes of conscious quality experienced by an individual, as would be the case with the classification of sensations (Gibson 1966:49). They also correspond to the organism's organs of active attention; in everyday life these perceptual systems, also known as external modes of attention, are simply referred to as looking, listening, sniffing, tasting, and touching. They are, however, not to be confused with the human passive abilities "... to *hear*, to feel *touches*, to experience *smells* and *tastes*, and to *see*, respectively" (Gibson 1966:51). Each perceptual system orients itself in an appropriate manner for the pickup of information from the environment, while being supported by the basic orientating system for the whole body. Expressed in more formal terms, the five perceptual systems are

- the basic orienting system
- the auditory system
- the haptic system
- the taste-smell system
- the visual system

Gibson's (1966:50) description in tabular form of the five perceptual systems is reproduced in Figure 4.1. The table includes information on the following: modes of attention, impinging stimuli, and external information obtained via the particular perceptual system[25].

[25]Information on the receptive organs and their anatomies are not of immediate importance for the present study.

Name	Mode of Attention	Receptive Units	Anatomy of the Organ	Activity of the Organ	Stimuli Available	External Information Obtained
The Basic Orienting System	General orientation	Mechano-receptors	Vestibular organs	Body equilibrium	Forces of gravity and acceleration	Direction of gravity, being pushed
The Auditory System	Listening	Mechano-receptors	Cochlear organs with middle ear and auricle	Orienting to sounds	Vibration in the air	Nature and location of vibratory events
The Haptic System	Touching	Mechano-receptors and possibly Thermo-receptors	Skin (including attachments and openings) Joints (including ligaments) Muscles (including tendons)	Exploration of many kinds	Deformations of tissues Configuration of joints Stretching of muscle fibers	Contact with the earth Mechanical encounters Object shapes Material states Solidity or viscosity
The Taste-Smell System	Smelling	Chemo-receptors	Nasal cavity (nose)	Sniffing	Composition of the medium	Nature of volatile sources
	Tasting	Chemo- and mechano-receptors	Oral cavity (mouth)	Savoring	Composition of ingested objects	Nutritive and biochemical values
The Visual System	Looking	Photo-receptors	Ocular mechanism (eyes, with intrinsic and extrinsic eye muscles, as related to the vestibular organs, the head and the whole body)	Accommodation, Pupillary adjustment, Fixation, convergence Exploration	The variables of structure in ambient light	Everything that can be specified by the variables of optical structure (information about objects, animals, motions, events, and places)

Figure 4.1 The perceptual systems (from Gibson 1966:50).

It is interesting to note that the perceptual systems can be influenced by learning; according to Gibson (1966:51),

[i]t would be expected that an individual, after practice, could orient more exactly, listen more

> carefully, touch more acutely, smell and taste more precisely, and look more perceptively than he could before practice.

In the sections below, the auditory, haptic and visual systems will be examined in somewhat more detail[26]. The aim is mainly to form a more complete understanding of the approach to perception on which action theorists have based their work, as opposed to the information-processing perspectives described in Chapter 2.

(a) The auditory system

According to Gibson (1966:75), the function of the auditory system is not merely to permit the individual the experience of auditory sensations, but rather to enable him to *listen*. The exteroceptive and proprioceptive functions of the auditory systems are described as follows by Gibson:

> Its exteroceptive function is to pick up the *direction* of an event, permitting orientation to it, and the *nature* of an event, permitting identification of it. Its proprioceptive function is to register the sounds made by the individual, especially in vocalizing.

The *listening system* consists of two ears plus the muscles for directing them to the source of sound.

(b) The haptic system

Gibson (1966:97) describes the haptic system as

> [t]he sensibility of the individual to the world adjacent to his body by the use of his body ... [I]t is an apparatus by which the individual gets information about both the environment and his body. He feels an object relative to the body and the body relative to an object.

The haptic system is equipped with receptors that are distributed all over the body; "... this diversity of anatomy makes it hard to understand the unity of function that nevertheless exists" (Gibson 1966:134). Its principal use is to obtain information about the environment; by getting hold of an object, a person can detect many of its qualities. In such instances, all these qualities are picked up by "... exploratory manipulation, that is, by the hands considered as a perceptual subsystem" (Gibson 1966:129).

Whether the use of the hands as perceptual systems is of particular importance for piano playing, is an open question. The sensations experienced by the various limbs, muscles and joints are probably of greater importance, and thus do not fall in this category, because the perceptual systems are concerned merely with information pickup, not with the qualities of sensation.

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[26]The basic orientating system has already been discussed implicitly in earlier sections dealing with posture, for instance Section 4.2.2.1, while the taste-smell system is not of relevance for the present study.

(c) The visual system[27]

The visual system is the perceptual system relied upon most by humans for receiving information about their environment.

In his efforts to point out how environmental stimuli impinge on the visual system, Gibson (1966:187-188) identifies eight subsidiary components to what he terms the *principles of ecological optics*, including *inter alia* radiation from a luminous source, reflection of light from surfaces, the network of projections in a medium, the ambient light[28] at a single convergence point, and the ambient light at a moving convergence point.

Schmidt (1988b:79) singles out as of particular interest the phenomenon of ambient light at a moving convergence point, i.e. the movement of the visual field when either the environment or the observer moves with respect to the other:

> As the individual and/or the environment moves, the angles of these rays [that strike the eye when reflected from every visible point in the environment] change to allow the subject to extract a pattern of movement from the changing visual array.

According to Schmidt (1988b:80), Gibson's above interpretation of how the visual system extracts information from the environment is of considerable importance for many types of sports and games, where patterns are relatively easily recognizable due to the large-muscle movements these games consist of. The same can apparently not be said of piano playing, which is mostly a matter of small muscle responses - especially in view of the renouncement by some piano pedagogues of the use of visual feedback in performance (see Section 3.2.1.3). The discussion on observational learning (see Section 5.2.2.2) seems to confirm this notion; therefore any further examination of Gibson's rather elaborate exposition on the visual system is refrained from here.

4.2.9 Piano playing as a goal-directed activity in the action systems theory sense

4.2.9.1 Technique and the aesthetic goal

Radocy and Boyle (1979:287) describe a *goal* as

> ... something toward which an organism directs its behavior ... All *purposeful* behavior is

[27]The evolution of the visual system, which is not of particular importance for the present study, is described by Gibson (1966).

[28]*Ambient light* is light reflected by the environment as a source (Gibson 1966:186).

directed toward a goal, which is not necessarily obvious, spiritually uplifting, or "important".

According to Starke, as quoted by Schmidt (1988a:13), the concept of a goal in the action context should be understood as follows:

> In the ecological (or action) approaches, the goal is an understanding of the mutual relationship between the environmental information and the motor behaviour that an animal displays; the focus is at the level of the animal-environment interface. It is almost like the old 'black box' approach to understanding behaviour ... in which input-output relations are the primary focus, and mechanisms occurring inside the 'box' are almost never addressed.

Apparently, the psycho-technical school of piano technique saw piano playing as a pre-eminently goal-directed activity in the sense described by Starke; according to Kochevitsky (1969:17), this school suggested that

> ... the more our consciousness is diverted from the movement, and the stronger it is concentrated on the *purpose* of this movement, the more vividly do artistic idea and tonal conception persist in the mind. Consequently, the artistic conception creates a desire for its realization, the will-impulse occasioned thereby becomes more energetic, the needed natural movement is found more easily ...

Many individual authors seem to have similar notions about piano playing; Fleisher (Noyle 1987:88) regards piano technique as

> ... the ability to do what you want to do. Therefore, you must want to do something, not just to go to the instrument and to put down levers in a certain succession at a certain speed. You must want a musical idea. You must have a certain intention, and the ability to do that is the index of your technique.

Whiteside (1961:3) defines the problem of piano playing as "... how to transfer what is a bodiless aural image into the ultimate contact of fingers against a keyboard of black and white keys", while Bolton (1980:11) and Lee (1977:6) define technique as respectively "... the ability to play (*a*) the right sounds, (*b*) of the right duration, (*c*) exactly at the required moment and (*d*) with a definitely chosen quantity and quality of tone", and "... a physiological and mental control of the bodily movements required in the production of an artistic performance".

It is indeed a well known and often-stated fact in the literature on piano playing that musical and technical development should go hand in hand. According to Schnabel and Wolff (Wolff 1972:22), "[i]n moments of great intensity, the spiritual and physical aspects of making music can become so completely unified that it is no longer possible to tell where one stops and the other begins". Neuhaus (1973:82) notes that the integration of the aesthetical side with the technical side should be a minimum requirement for the process of learning to play the piano; it is in fact ideally desired that musical insight should start to be developed *before* the development of technical skills. According to Prostakoff and Rosoff (Whiteside 1969:20), Whiteside even believed that the human body is so constituted that the physical coordination used when emotional involvement is present in a performance is different from the physical coordination used when emotional involvement is absent, a view which is shared by Fleisher (Noyle 1987:92-93):

> ... when you ... impose a musical intention upon the passage that you've worked out purely physically, there comes to the physical a different kind of emphasis, a different kind of stress, a different kind of tension ...

According to Prostakoff and Rosoff, Whiteside was the first to uncover that there is in fact a physical basis not only for virtuosity, but also for continuity and aesthetic beauty in performance (Whiteside 1969:9). Thus Fielden (1961:3) notes that the ingenuity and inspiration of so-called great players "... conveyed itself to their physical movements as well as to their aesthetic expression: indeed their aesthetic expression was the result of their physical movements".[29]

On the other hand, a case can also be made out for the reversal of the order of things; Fielden (1961:161) states that a good interpretation is impossible without a sufficiently developed technique - "technical lapses are apt to cause discomfort sufficiently to detract from the fulness of spiritual inspiration which the interpreter may wish to convey". He warns against the "very dangerous" tendency to put technique second to interpretation; a tendency which often manifests itself in arguments contending that a good interpretative effort with inadequate technique is preferable to a technically brilliant performance lacking in aesthetic substance. According to Fielden, the former predisposition could "... reduce any art to mere dilettantism".

While the aesthetical side of piano performance supposedly is to be a major help in approaching and conquering the pianist's technical problems, it is worthwhile to note that a lack of technical proficiency can inhibit the pianist's inherent musical qualities, and thus his aesthetic intention, from being deployed to the full, even in the case of the extremely gifted. An example that stands out is that of Ashkenazy (Noyle 1987:7), who comments as follows on his early years of piano study: "[m]y love for the music I heard around me was tremendous, but because I had to overcome physical obstacles on the piano, I suppose I stupidly wasn't expressing very much". Schnabel and Wolff (1972:22) refer to the "gap" that can arise between the mental conception of a piece and its physical realization: "[t]he audience wrongly receives the impression that the performer does not like or does not understand the piece, whereas he is simply unable to bring his conceptions convincingly to the fore". In view of the above, the viewpoint of Gieseking and Leimer (1972:47), that it is harmful to pay attention to the interpretation of a piece while it is being studied, because the student is too preoccupied with the technical problems, does not come entirely expected.

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[29]It is interesting to note in this context the similar views of two eminent pedagogues on the subject of fingering. According to Neuhaus (1973:141), in fingering physical convenience comes secondary to an accurate rendering of musical meaning, for example phrasing; it can be observed from the examples provided by Neuhaus (1973) that this does not necessarily imply that a "musical" fingering is inconvenient. In a similar vein, Bolton (1980:10) points out that the "right" fingering is the "... easiest fingering that will give us the right phrasing".

To take the above arguments even further, a particularly astute comment by Schultz (1936:vi) on the technique-versus-musicality issue is reproduced here: according to him, a subtly concealed fear is prevalent under pianists

> ... that a persistent use of the reasoning mind in reference to the objective phenomena of technique results finally in the deterioration and atrophy of the subjective emotions upon which the interpreter's art depends.

Schultz is of the opinion that this fear

> ... explains the defiant and insistent sentiments with which theorists are wont to commingle their technical precepts - sentiments all handsomely to the effect that *music*, after all, is the thing. It explains the ever present *bête noir* of all our pedagogy - *over*emphasis on the technical phases of playing. It explains the sharp resentment of technique which is unaccompanied by interpretative insight, as if the technique were the *cause* of the emotional insensibility.

Another counter-argument to the notion that technique will "come naturally" when interpretation or musical expression is made the focus of attention, is expressed by Ashkenazy (Noyle 1987:6) as follows:

> ... the more I play, the more I think about everything, the more I come to the conclusion that the more you want to express, the more difficult it is to do everything. The mechanical problems are such that you can really almost overcome everything. But when you want to do something, then everything becomes difficult ...

This, however, does not prevent him from relying on a *Gestalt* approach to music making (Noyle 1987:8); "... I always have the overall view in my mind whenever I do anything".

4.2.9.2 Whiteside's approach to piano playing

The present section will investigate the rather original approach to piano playing of Abby Whiteside, which appears to be relevant in an action theory context for reasons that are explained below.

Whiteside's philosophy of technique was essentially aimed at bringing about a so-called "natural" coordination in her students[30]. Bridges regards Whiteside as a *Gestaltist* in the sense that she wanted the body as a whole to transfer the idea of music into the actual production of music (Whiteside 1961, 1969):

> ... although she did not go on to say this explicitly, most of the imagery she used to describe coordination - her unique concept of rhythm, her concentration techniques - all pointed to this body Gestalt. (Bridges 1985:57)

According to Whiteside (1969:41), the combinations of actions in playing the piano cannot be

[30]According to Prostakoff and Rosoff (Whiteside 1969:3), Whiteside in fact tried to convey to her students the effortless kind of physical activity used in improvisation - commonly found in jazz pianists - to the playing of the "classical" piano literature.

isolated; it can however prove useful to be aware of certain combinations of actions in order to prevent bad habits from forming. The emphasis on using the playing apparatus as an integrated system, rather than concentrating on the workings of individual limbs, is well illustrated by Whiteside's (1961:69) explanation of how large horizontal distances should be traversed at the keyboard: in particular, easy control of horizontal distance lies in the use of the upper arm, which is the only section of the arm "... which can produce a coordinated action and right balance in activity with all the other levers". Being able, due to the turning of its bone in the circular shoulder joint, to function in any plane, slight movements of the upper arm make possible large actions by the forearm. Also, the hand should not be trained to act independently from the arm, as the hand functions as part of the whole as well (Whiteside 1961:48).

It is of some interest to note here that some authors extend the physical *Gestalt* idea to provide for the instrument as well in the plan of things. Kessler (1981:31) thus states that "[j]ust as the violin lies inside the violinist's arm or the cello stands between the knees of the cellist, the piano and the pianist should become one entity". Fleisher (Montparker 1986:11), however, points out the rather obvious fact that pianists can not be compared to orchestral instrumentalists; "[p]ianists can put down a note and go out and have a cup of coffee - that's how connected the effort is to the sound".

Implicit to Whiteside's approach was her concept as a *Gestalt* of the music as well; in this regard Prostakoff and Rosoff (Whiteside 1969:4) note that Whiteside's approach to technique differs from all other teachings, in the sense that other approaches deal with the production of individual tones when addressing the physical motions involved in playing; there is nothing which deals with the production of a phrase.

A recurring theme in Whiteside's writings is that of an all-encompassing rhythm, which is the underlying coordinating factor in piano technique. Unfortunately, in spite of the various references to this rhythm scattered throughout her two most important monographs (Whiteside 1961,1969), the precise meaning of the concept, as well as its application to piano playing, remains somewhat enveloped in vagueness[31]. Gerig (1974:474), citing Whiteside (1969:10-11), manages to synthesize the following rather coherent description of the concept of an all-encompassing rhythm:

> In Abby Whiteside's teaching an all-encompassing, long-line rhythm moves down through the music for the pianist outlining the phrases and pointing up the form. It gives a feeling of flow and continuity of movement and tends to interrelate each note to every other one. Without it, a sense of timing in performance ... [is] impossible. She observes that this fundamental rhythm is especially noticeable in an orchestral performance. The first-chair men can be spotted immediately "by their swaying bodies as well as by listening to their lilting phrases". ... But left on his own the pianist does not have the benefit of the singer's breathing, the

[31]Bridges (1985:57), rather appropriately, notes on this rhythm that, "[b]eing a non-verbal experience, it was difficult for Whiteside to describe".

> violinist's bow arm, or even the skater's balanced activity to force him into a long-line phrase procedure and a compelling rhythm in his body. He must use full arm and bodily participation in order to achieve such a rhythm.

According to Whiteside (1961:14,38), the upper arm can be regarded as the prime coordinator of the basic, phrasewise rhythm. But Gerig (1974:475) also points out the rather curious notion that "[t]he torso itself frequently must bounce and dance to the music".

Another important aspect of Whiteside's technical approach, which also appears to have certain action theory premises as basis, is that she defines the motor tasks required for piano playing *functionally* through the use of imagery. The reasons why imagery delivers better results than an explicit account of the action of levers in terms of the nature of muscles to act in areas is explained by Whiteside (1961:60) as follows:

> Muscles act in areas, and when imagery stimulates a coordination there is no boundary line for these areas. There is, instead, cooperation from all the areas. When good imagery suggests a result there are far more chances for nature to take over the coordination in a skilled manner than when a so-called factual analysis of leverage is made.

Whiteside (1961:60) continues to clarify the goal-, or image-orientatedness of her approach to piano technique as follows: "[a]ll we need is a desire, an imaged result, and we move and act expertly to get the thing we desire. What we do in action as a means to the result, we are totally unaware of most of the time". Unfortunately, in applying her ideas to their fullest consequences, Whiteside sometimes comes to rather contentious conclusions, for example (Whiteside 1961:50): "... the importance of a prescribed fingering is practically nil ... If a rhythm is working, a finger will be ready to deliver power".

4.3 The action systems approach to motor learning

Reed (1988:79) distinguishes between the nature of motor skill learning under the motor systems approach and its nature under the action systems approach as follows: when traditional theories of motor learning are concerned, skilled actions can be described as displacements of bodily limbs in space, and

> ... learning a skill as an adult, or developing skills as a child requires the acquisition of specific neuromuscular units of movement, along with the motivational and cognitive abilities to control and constrain these movements.

When, on the other hand, skilled movements (actions) are considered to be constituted by

> ... ecologically orientated postures and the movements that change them in the service of particular functions, then skill learning involves the acquisition and coordination of a number of basic acts for each of the several human action systems.

The latter concept of learning involves what has been described by learning theorists as *practice without repetition*; learning of a skill then "... is not the acquisition of a pattern of movements, but a functional organization of whatever postures and movements serve to get the job done" (Reed 1988:79).

According to Reed (1988:80), exceptions do exist where learning the skill involves learning to make a specific movement pattern; he cites dance, sports like gymnastics and even some music skills, as cases where it is required that certain movements should appear "correct" to a judging observer. This fact, however, does not nullify the functionality argument, as it is debatable whether human observers judge movements by quantitatively analyzing spatial displacements of limbs.

Finally, Van Wieringen's (1988:113) notion should be pointed out that the action approach is not suited to the explanation of motor learning, because cognitive structures are avoided.

4.4 Limitations of the action systems approach as seen from the motor systems perspective

While Schmidt (1988a:14-15) welcomes the shift in focus proposed by action theorists towards the role of the environment as determinant for motor control, he is however

> ... compelled to ask, "So, how then do we actually *move*?"

in view of action systems theory's lack of analyzing the events inside the "black box"[32] in the sense that information-processing, for example, is explained under traditional motor systems theory (see Chapter 2). Van Wieringen (1988:89) is of the opinion that motor systems theories are a *sine qua non* "... if it is wished to explain more than a very restricted subset of relevant data".

Perceiving an apparent difference in levels of analysis, Schmidt (1988a:13) declares that the action view's focus on the goal in motor behaviour forms an excellent basis to point out the differences between the action and motor approaches

> ... in terms of *what* is the target of explanation. In the action view, the explanation is in terms of what the motor view would term 'input-output' relations, while in the motor view it is usually in terms of mechanisms of motor control. More fundamentally, the difference seems to be in terms of the *levels of analysis* at which the theorizing occurs.

Thus, Schmidt (1988a:14) prefers to state that it is probably not valid to weigh the motor perspective against the action perspective, because these theories attempt to explain different things,

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[32]This analogy will be discussed in Section 4.2.9.

although admitting that the two approaches are not operating at totally different levels of analysis. Schmidt, as a motor theorist, is conspicuously far from declaring action systems theory as outrightly wrong, contrary to certain action theorists' stance on the motor program.

4.5 Summary and conclusions

Action theorists dismiss the motor systems approach to motor control and learning as an incorrect application of the computer metaphor to humans. A major argument in support of this statement is that the peripheralist-centralist dichotomy adhered to by motor theorists is not valid for the reasons pointed out by Reed. The nature of the internal representations and cognitive structures assumed by motor theorists to account for motor control and information-processing in itself requires explanation, thus giving rise to more questions instead of solving the present ones. Motor theorists regard all movement as built up out of neuro-behavioural units; action theorists, however, feel that these basic units should rather be defined ecologically.

A common goal for action and motor theorists is to identify how the degrees of freedom available to the organism is constrained, so that the control of a number of degrees of freedom to form a motor response is handled as a single unit. Motor theorists advocate the motor programming idea, but action theorists adhere to the idea of a coordinative structure, i.e. a group of joints and muscles acting together as a unit.

Actions were shown to differ from the motor systems theory concept of movement in that they are functionally defined in terms of the organism's interaction with the environment, while movements are merely defined as displacements in space and time. The constituent subsidiary components of actions are functionally defined actions themselves. Postures and movements, in themselves actions, were identified as the constituent components of any action, postures being the orientation components, with movements the functionally nested changes in posture. While the ultimate posture in humans is to maintain an upright posture, the goal of this action being to keep the perceptual systems orientated to the environment, the method presented by Taylor suggests that posture can also serve the purpose of equipping the pianist with the ultimate in coordinative powers, i.e. technique. In particular, by cultivating what Taylor terms the expanding posture, the performer will be able to play anything he can sight-read almost at the first attempt. While Taylor's approach seems to be extremely attractive due to its doing away with piano practice in the traditional sense, achieving the expanding posture seems to be a highly sophisticated affair, at least in the initial stages; guidance by a qualified teacher seems to be imperative. The fact that Taylor's approach is apparently built on a single principle only, i.e. the virtues of the expanding posture, intuitively gives rise to some concern;

as Schnabel and Wolff (Wolff 1972:23) point out, "... gymnastic considerations have lead some teachers to building their training on just *one* facet of body activity ...". Taylor furthermore supplies no findings obtained through scientific experiment to support his thesis; more research is necessary to determine in an empirical manner whether the expanding posture indeed increases coordinative facilities for piano playing, and whether a positive finding in this regard will have any implications for the action notion of skilled motor behaviour.

The inadequacies of traditional motor systems theories are exposed to the fullest when required to explain postural precedence effects. The influence of postural precedence effects on piano playing requires some further investigation; experiments based on motor systems premises, however, would seem to be unsuited for this purpose.

It was pointed out that humans at any stage are involved in a variety of functional activities which overlap continuously; thus various action systems are running at the same time, each of which consists of various action cycles, which in turn are comprised of the postures and movements that are functionally selected to comply with that specific task goal. To illustrate the foregoing, it can be postulated with respect to piano playing, that one action cycle governs the right hand and another the left hand. These cycles are nested within another action cycle that controls the hands playing together. A different action system is concerned with maintaining the seated posture at the piano, while another action cycle regulates pedalling. At the same time, a multitude of action cycles are involved in the coordination of less obvious movements and functions. The problem of explaining human motor behaviour thus becomes one of explaining how various streams of activity are nested into unified acts, and how some of these streams are kept to cycle separate from each other. At the present time, however, initial research into this matter has not even gained momentum yet, and this fundamental question thus remains unresolved.

It is not clear which basic actions are underlying to the movements of piano playing. Reed's statement that it is not even known yet how the postures and movements involved in the basic skills of everyday life should be characterized does not auger well for a scientific understanding of highly refined motor skills such as piano playing.

An investigation of the literature on piano methodology reveals that the hand is often regarded as a tool for piano playing. Traditional motor control theories cannot be used to explain tool use. This makes the realization that tool use was required of test subjects, in many (if not most) of the experiments substantiating various motor systems theories of motor control and learning, all the more disquieting. Any research efforts to elevate the understanding of human tool use beyond its present highly rudimentary state, could hold some advantages for piano playing as well.

The dynamical systems explanation of human movement is seen by certain action theorists as a complete negation of the need for elaborate centrally-driven motor programs to control movement. Motor programming theorists however point out that, as in the case of motor programs, unanswered questions remain on how the differential equation setup which organizes the relevant movement patterns originates. Certain movement patterns in piano playing would intuitively seem to be well suited to description along dynamical systems lines, and as such should be worthy of some further research.

The ecological view regards pickup of information from the environment as direct, not requiring the elaborate information-processing associated with the motor systems view. According to Gibson, the different senses should not be regarded as mere passive producers of sensations, but rather as interrelated perceptual systems, or active mechanisms for looking, listening, touching, and so on, which orientate themselves appropriately for pickup of information from the environment. An individual can learn to use his perceptual systems more effectively, which accounts for the comments made on the use of intrinsic feedback in the previous chapter. The implications of dealing with perceptual systems, rather than passive receptors, for piano playing can only be speculated upon in view of the lack of experimentally-verified findings.

Various references to piano playing as a goal-directed activity in the literature, the goal being a certain aesthetically-justifiable musical concept, seem to confirm the notion that piano playing can indeed benefit from a functional approach to its problems. It is suggested that concentrating on the goal will cause motor execution to follow in a "natural" manner, i.e. in a manner ecologically appropriate for the task, or that motor execution will at least be greatly facilitated because of an inclination towards being functional in nature. Other authors, however, contend that no aesthetic expression is possible if a sufficiently strong technical basis does not exist beforehand, rendering this matter somewhat uncertain.

It was found that various aspects of in particular the approach of Abby Whiteside suggest an implicit action approach to piano playing. Whiteside states that the combinations of actions in piano playing cannot be studied in isolation, in effect acknowledging the idea that many action systems and cycles are running at the same time, constantly overlapping and nested within each other. She sees the playing apparatus as an integrated system rather than in terms of the workings of individual limbs; in this regard one would be inclined to refer to the piano playing system in a sense similar to Reed's action systems and Gibson's perceptual systems. Movements are functionally defined; therefore it is apparently not necessary to use a prescribed fingering, i.e. the planning of finger movements in terms of space and time. In particular, imagery is used to functionally describe movements in piano playing; movements are not described kinematically or dynamically, i.e. in the traditional motor systems theory sense. The state in which the pianist functions in harmony with his playing environment, i.e. when all playing occurs "naturally", is synonymous with Whiteside's idea of an all-encompassing basic rhythm.

Whiteside appears to have many staunch followers who have benefited from her methods. It is however not quite clear from her monographs precisely how this basic rhythm can be established in pianists unfamiliar with her approach, i.e. how learning of technique takes place. The general attractiveness of her methods, which can in part be attributed to the fact that no distinction is made between practice and performance, clearly warrants some further, scientifically-based empirical investigations. Until then, it is not possible to assess their validity.

The action approach to motor learning appears to be rather vaguely defined at the present time; some authors even regard action systems theory incapable to explain learning because of its avoidance of cognitive structures. The action idea of practice without repetition, which involves the functional organization of postures and movements to get the job done, appears to be particularly attractive. More research is clearly necessary to initiate clarification of this matter.

It was pointed out that action systems theory has exposed many of the shortcomings of the motor systems approach; some motor theorists however hold that the action approach does not offer any viable alternatives to their explanation of how humans move. Also, action theorists seem to avoid in their discussions the topic of highly skilled motor behaviour such as that found in piano playing; instead, the emphasis appears to be on the phylogenetic skills.

The action systems approach, nevertheless, is acknowledged by both Adams (1987) and Schmidt (1988a) to be a main line of research for the future, and it is believed by Reed (1988:81) to have the potential for representing a radical new start in man's study of human action:

> ... Gibson's ecological psychology, with its theory of action as based on what the environment affords the animal, and on the pickup of information specific to these affordances, by an agent's active perceptual systems, provides an entirely new and promising beginning for studying action in a way that will be relevant to practical concerns.