Int. J. Sport Psychol., 1999; 30:41-62

Individual Preconditions for Mental Training

JÖRN MUNZERT* and DIETER HACKFORT**

** Institute for Sport Science, University of Giessen, Germany*
*** Institute for Sport Science and Sport, University FD Munich, Germany*

Based on the conceptual background of action theory mental training is regarded as a special kind of situation anticipation and the content and function of the imagery process is emphasized. A particular stress is placed on the recording of individual imagery ability which is regarded as the essential determinant for the efficacy of mental training. Suggestions for the improvement of the relevant procedures in such training programs are provided.

KEY WORDS: Action, Anticipation, Imagery, Motor images.

Mental training as an image for action

Mental training can be regarded as a – if not «the» – classical form of psychological training in the learning of a movement at the workplace and in sports. It was systematically developed and investigated at first to improve learning in the motor learning process in industrial settings (Ulich, 1965; Wunderli, 1978) and conceptualized also for its application in sports by Volpert (1983). From the perspective of these authors it presents, in addition to the observational and verbal training, a focal point in the cognitive accentuated training methods. Especially in elite sports its use is not restricted for motor learning but it is also practised in competition preparation. In this regard is it sometimes less skill oriented and the focus is more on activation. In the performance preparation process it also serves as a psyching strategy. Already Paivio (1985) pointed out that imagery has cognitive and motivational effects. It is assumed here that the functional meaning of mental training has to be regarded in more detail and can be differentiated with respect to the learning process – where

Address for correspondence: Prof. Dieter Hackfort, Istitut für Sportwissenschaft und Sport University BW München, Werner – Heisenberg – Weg 39, D-85577 Neubiberg, Germany.

it is skill oriented and cognitive accentuated, and the performance preparation process – where it is activation oriented and affective accentuated. These aspects are fundamentally different for the practice of mental training and have to be considered in theoretical concepts for the development and different application of this method.

The following considerations are determined by an action-theory perspective emphasizing motor actions as intentionally organized and purposive behavior. The organization of actions is based on the anticipation of situational demands which have a subjective meaning for the individual (Hackfort, 1986, 1991; Nitsch, 1986; Nitsch & Hackfort, 1981). From this point of view mental training is primarily regarded with respect to situation anticipation and the focus here is on mental training as *systematic self-imagery of task performance*. Before a more exact differentiation of its meaning from an action perspective is explained, it should be clarified from which concepts it *differs*. At first viewing mental training as containing all forms of visualisation as a means of influencing the mental training of a subject. This includes almost all types of psychological influence during the training process. In addition, mental training has to be differentiated from those perceptions under which only the reproduction of a stereotyped movement pattern is understood, which in turn creates a particular imagery. The second perception does not represent a contradiction to other exclusive descriptions. It is rather to be integrated as a component of the wider action-theoretical concept.

In the action-theoretical context it is possible to differentiate mental training as a form of *situational anticipation*. A description of the phenomena of an anticipation could, for instance, include a person imagining himself entering the shot put ring, putting the shot with a particular technique and «seeing» the flight of the shot. From the memory aspect one would call up episodic characteristics of the action from memory which could then be further differentiated into their modality specific parts. Central to mental training are thus questions concerning the relationship of visual and kinestetic images. However acoustic imagination (for instance the edge grip in skiing) can play an important role. These single aspects are however part of a more or less clear and complete situation anticipation. The situation concept is theoretically broken down into characteristics of the person, the task and the environment (Hackfort, 1986; Nitsch, 1986; Nitsch & Hackfort, 1981). With regard to the imaging of a task performance, this includes the *performing person* as part of the situation. It is not possible to image an action without an actor. The task, that is the mastering of the task, refers to the imagery of the movement, but also to the preparation and interpretation phases of the action (Hackfort, 1991; Nitsch & Hackfort, 1981). The perception of

mental training which is characterized as too narrow thus accentuates only one part of the situation, the mastering of the task, and therefore only one aspect, that is the progression of the movement. The third aspect of the situation concept concerns the environmental conditions. These can be either conditions connected with the performance of the task (the snow covered slope as a condition for skiing) or material effects of the movement (the flight and landing of the shot).

Because of the specificity of the tasks, special instructions and varied individual conditions can either emphasise or neglect individual aspects of the situation anticipation. Depending on the characteristics of the person this may concern for instance the reality of the imagined actor: this can vary from a vague or schematic to a concrete image of a particular person. It is possible to further differentiate whether one imagines oneself or another person. In the use of mental practising in the early learning phases, in which it is used in the framework of model learning (Müller, 1994), and also in its use in later learning phases, where the optimisation of task performance is concerned, the important learning effect is based on self-participation and the actualisation of one's own problem solving.

Many instructions in the imagery process focus on the motor completion and the engagement, of the kinestetic impressions involved. Depending on the task it is also wise to accentuate the phases of task planning and interpretation. When processing of feedback in connection with mental training is examined, it is usually whether feedback can be registered through the program activated by imagination (Heuer, 1985; Pickenhain, 1976). In the action concept, on the other hand, it is described that feedback from previous activity episodes may be remembered and under certain circumstances further differentiated. In this way analysis of the origins of mistakes in less successful task performances can be undertaken.

To what extent environmental conditions are included in the imagery depends on the nature of the task. In sport disciplines in which the athlete's own motor completion must be coordinated with external conditions, the imagery of the task performance must contain such environmental conditions to a high degree. On the other hand, it is also possible to concentrate in imagery on the «pure» movement process and ignore many environmental features. The possibility of accentuating various components of task performance allows for various forms and contents of mental training. A limitation in the sense that not every imagery, also not every movement imagery process, can be understood as mental training is especially possible through the goal orientation which is connected with this form of training. In the following text mental training is considered as a method which is based on the

imagery of task performance with the *goal of improving the task related competence in the framework of a long term learning process.*

In this theoretical framework the above mentioned psyching aspect [motivational aspect; activation aspect with regard to performance preparation] (Paivio, 1985) of mental training has a special link to action regulation processes. Two processes are differentiated in the realisation phase of an action: 1) tuning and 2) processing. Whereas processing refers to the psycho-motor functioning responsible to realize the goal directed movements, tuning refers to the activational preconditions for optimal functioning, e.g., to induce or amplify arousal in order to activate full power and energy (psyching up) or to reduce arousal in order to overcome excitation and nervousness (psyching down). The later processes (psyching which refers to tuning) have a special functional meaning which is differentiated from the skill oriented aspect and psycho-motor processes emphasized in mental training. These (psyching) processes or methods are not discussed here.

Furthermore, mental training can be differentiated from movement imagery which often occur in the framework of action planning, where an athlete anticipates and «plays through» the action in the imagination. This happens in principle with the intention of preparing for and supporting the subsequent action, and not necessarily of achieving a learning effect. As already mentioned above this possible form of mental practice serves mental preparation as it refers to the preparation for competition and it is performance oriented, which should be considered a special strategy.

This action- theory based understanding of the concept «mental training» makes clear why certain forms of mental training are favoured, and why specific questions, for instance whether expected or actual values of the task performance should be imagened, are discussed (Volpert, 1983). However, we should not forget that skill orientation and activation orientation etc. are conceptual differentiations which are analytic and it is not possible to exclude the effect of mental training on motivational processes when practicing this method. Nevertheless, the influence of movement imagery on movement learning remains prominent.

The various concepts and areas of application of mental training makes it difficult to compare the manifold research on mental training in motor learning. From the available meta-analyses (Feltz & Landers, 1983; Feltz, Landers & Becker, 1988) it appears that the effect of mental training is not as strong as one may believe. In order to be able to evaluate hypotheses about the effects of mental training, or their lack we will discuss results from the imagery research with special emphasis on the functional meaning of mental training for motor learning and skill development.

Is Imagery Based on Sensory Experience?

Most attempts at a definition stress the close phenomenal relationship between the imagery process and the perceptional process. Images are based on the perceptional experiences without the actual presence of the imagined objects, and without an equivalent sensory input being present (Kosslyn, 1987). Visual imagery is usually studied but theories also exist regarding other sensory modalities.

In order for such images to be created and lead to subjective sensory experiences something analogous to sensory input must exist. This analogue is based on perceptional information which is called up from the memory. It is therefore necessary to assume at least two steps in the process. Information is called up from the *long term memory* and brought into the *short term memory.* There it calls up the experience of an image (Kosslyn, 1987). Only in this phase the images can be manipulated: for instance in classical experiments on mental rotation.

First, we need to demonstrate that images actually show characteristics similar to those of perception. In addition to the subjective viewpoint a whole series of experimental results are introduced. In this way optical illusions with the Müller-Lyer figure can also be produced by imagery processes (Berbaum & Chung, 1981; cited in Perrig, 1988, p.44). Certain colour aftereffects with the so called McCullough Effect can also be created with limitations through imagery processes (Finke & Schmidt, 1977). Further proof for the connection between perception and imagery is the finding that the time for the «mental observation» and «scanning» of an imagined object is dependent on its actual size. So it is not only the subjective impression that imagery is perceptional representation, but this can be made far more apparent through the parallels in the way in which tasks of perception and imagery are solved.

The aim of the neurophysiologically orientated imagery research (Farah, 1988, 1989; Goldenberg, 1987; Jeannerod, 1994) is to demonstrate that the same definable neuronal processes are involved in perception and imagery. Through electrophysiological techniques or by measuring the local cerebral blood flow it can be shown that the identical brain centres are activated (Goldenberg, 1987). In addition patients with certain brain syndromes frequently have specific disturbances in their perception processes which correspond with the equivalent disturbances in the imagery process.

It does not follow from the existence of common neuronal processes during perception and imagery that the memory components from which the images are built up represent relatively basic traces of the perception processes. The imagery debate is also concerned with the question whether one has to assume a separate (pictorial) representation system for pictorial imagery, or whether the pictorial images are also generated on the basis of meaning structures. The concept of meaningful processing and storage of perceptional contents is to be preferred to the sensory- storage concept. This also means that images are *reconstructed* from meaningful structures. A proof of this assumption is that the storage and the remembering is dependent on the particular context. It can be shown that incomplete information will be automatically completed, as befits the overall concept.

That the activation of the common neuronal structures of perception and imagination cannot be seen as identical with the perception and imagination content is shown in the results of imagery process research conducted with blind people (Marmor & Zaback, 1976; Farah, 1988). Congenitally blind people show similar performances in imagery tasks such as mental rotation or mental scanning to test persons with regular sight in comparable original experiments (Kerr, 1983). It is therefore possible that people who were born blind use the intact «visual» neural structures in imagery tasks despite the lack of on visual sensory information.

How Are Motor Images Constructed?

The answer to whether images originate on the basis of reactivated sensory impressions, or on reconstructed meaning structures, has relatively direct consequences for the concept of movement imagery. The first concept corresponds in this area to the fact that motor imagery is a derivative of motor programmes, the second that motor imagery includes meaningful episodic sequences, including task performances.

Motor imageries as situation anticipations relate mainly to *distal events of the task* (Prinz, 1991, 1994). The distal effect includes above all environmental changes. An (interesting) special case is the movement forms in dancing or gymnastics. Whereby the environmental change is based purely on the movement of the body, without altering further objects (such as apparatus). But even for the movement in a racquet game the situation of a «pure» motor imagery is still quite normal. Frequently in training, sometimes quite automatically, «simulated movements» without ball or racquet are carried out in order to «drill in» the movement pattern and to recollect certain sensations. Here too we are concerned with distal characteristics of the the task and not with the imagery of the processes of the movement production.

The differences between proximal and distal effects can be demonstrated with the help of a transfer experiment by van Gyn, Wenger and Gaul (1990). The basis was a sprint specific maximal strength training on the bicycle ergometer. After a six week training period the groups with only maximal strength training, and those with maximal training combined with an imagery instruction, improved their performance to approximately the same extent. The special feature of the instruction was that the group with the mental training was meant to imagine the «aimed-for movement» of sprinting during their strength training. In the studied sprint performance only the group with the combination of maximal strength training and imagery instruction improved. The maximal strength training group could not apply their strength gain to the sprint movement. A control group which training only carried out mental training showed no significant improvement either in maximal strength or in the sprint task. During the training phase the proximal training effect and the distal imagery are separated for the imagery group with maximal strength training, in the transfer phase only this combination leads to a significant progress.

When one accepts this concept of motor imagery the concepts which interpret motor imagery as a consequence of the activation and inhibition of motor programmes become problematic. This is exactly what Prinz (1994) criticizes about the concept of Jeannerod (1994). As soon as it is assumed that motor imagery preempts intended effects, one no longer moves on the level of the motor programme, but on the level of the action with its distal representations. The motor imageries are greater than the contents of the motor programmes.

The «internal view» in motor imagery (Mahoney & Avener, 1977) deals with an expression that found its way from the area of sport into the area of general psychology. One can differentiate at least three meanings for this expression. They have in common the emphasis on kinestetic motor sensations during imagery. The first variant treats it as a peripheral, but for the training's efficacy central, side effect. It comes in addition to the external visual view. This becomes more apparent in the second variant, where only the «inner» kinestetic sensation is labelled as the internal view. The third variant represents the actual opposite of the external view: in which the updates of the visual information which one would have as the performing person are named as the internal view. This would be comparable with a film recorded with the helmet camera during skiing. In this variant one assumes that one perceives very intense kinaesthetic sensations.

All three variants of the internal view still include the intended distal effects. In contrast to the external view however stronger kinesthetic processes are emphasized (White & Hardy, 1995). At this point the dividing line between proximal and distal processes is blurred. Here the possibility of a connecting link between the two levels exists.

How Does Mental Training Take Effect?

The motor imagery is thus not identical with the programmes which produce the movement – as Jeannerod (1994) in part assumes (Prinz, 1994; Vogt, 1994, 1995) – but is connected. This connection shows itself in two phenomena. It can be shown that during imagery a part of the neuronal structures that is relevant for the execution is activated (Heuer, 1985; Jeannerod, 1994). The peripheral psychological effect that the corresponding muscles are activated is also known as the "Carpenter Effect" (Volpert, 1983). It is especially with the second aspect that a series of hypotheses and speculations about the effect of mental training tie in. Suggestions exist that these ideomotoric effects are a result of the activation of task specific programmes (Harris & Robinson, 1986; Wehner, Vogt & Stadler, 1984). But it is hard to explain how these peripheral effects in themselves can contribute to the effect of mental training.

Following these results one can discuss Heuer's (1985) «programming hypothesis». The starting point for this assumption is that the same central processes that are activated via the motor imagery, also direct the execution of the movement. This is exactly what the physiological results seem to confirm. The execution of the movement would be inhibited shortly before its initiation, the ideomotoric phenomena would then be concomitant effects of this process. Where does the learning effect lie in this process? According to Heuer (1985) it is based on the very simple process of practice and repetition. This is in so far not trivial as the programmes are not simply called up but have to be constructed respectively. In addition they have to be connected with the phenomenal features of the motor imagery. A series of processing steps is necessary which can be consolidated and improved through repetition.

Instructions to concentrate on the motor sensations can lead to a heightened muscle activity (Hale, 1982; Harris & Robinson, 1986). The hope of thus capturing the more intensive processes of mental training, which will then lead to greater learning progress, should be viewed with scepticism. At least in one study by Wiemann (1975) it was shown that no such dependence of the learning performance on the intensity of the peripheral muscular activities during the imagery process existed.

With the programming hypothesis the effects of mental training are postulated on a relatively basal and motor level. Such effects should be specifically relevant for highly automatized and cyclic movements where it is often suspected that mental training plays at, the most, a subordinate role.

This leads to the second so-called «cognitive hypothesis» of mental training. This counts as empirically most valid, and is generally accepted. The empirical validation is based on an intuitively apparent, but empirically and theoretically very problematic differentiation of task performances with cognitive and more motor components. It is considered as proven that mental training is effective especially in cognitive tasks (Feltz & Landers, 1983). One should be cautious with the designation «cognitive» in the classification of the task. One could better differentiate between learning tasks that demand practical execution to a high degree and those in which this is not the case. Balancing tasks are often given as an example for «motor tasks». It is undisputed that such tasks can be mastered after sufficient practice. But this does not mean that cognitive processes do not play a part here. On the contrary manifold learning strategies can be observed during experiments with the stabilometer, some of which may be changed in the learning process. Such strategies concern for instance decisions in which way the countermovements are made (for instance by means of arm movements or movements of the lower extremities). So cognitive processes play an important part, but successful learning is strongly dependent on extensive practising.

The nucleus of the cognitive hypothesis is aimed at the improvement of the symbolic and spatial representations of the movement process (Heuer, 1985). In the process of the movement different parts of the task have to be integrated (sequential aspect), parallel sequences must be coordinated or modified (parallel aspect). Both aspects are concerned with the concept of multiple tasks, as was developed by Kaminski (1981). The individual movement characteristics can be transposed relatively easily, especially the *coordination* of the individual parts is practised in the imagery process. In this way a semantically uniform action gestalt can be created. A parallel organization of the motor level does not have to go hand in hand with this. Many performance errors arise exactly because of the disconnection of the two organization processes. One case can be observed when a complete sequence is developed in the imagination but the motor level does not follow it and «stoppages» arise in the process. The second case concerns an imagery which is variable and changeable but which cannot be transferred because a motor automatization or stereotype is occurring. Positive effects of mental training in

this area can only be explained when the cognitive and programming hypotheses are combined.

One may give special attention to the temporal progress during motor imagery. Here also close connections between motor imagery and the motor representations may be observed.

Temporal characteristics can, under certain circumstances, serve as a translation between the different representation types (Prinz, 1985). Such temporal characteristics can refer to the absolute time duration of the total process, or to the temporal structuring of the imagery and performance components. In the second temporal aspect a relationship to the «relative timing» on the level of the motor representation becomes apparent. On the imagery level temporal accentuation and structuring of the performance process is often combined with rhythmic experiential components. They are especially taken up in the so-called «rhythmic teaching methods».

Whilst the above-mentioned temporal aspects relate to the movement process in its narrower sense, and thereby show relatively direct correspondence to the motor representations, a third temporal aspect of the kinesthetic imagery clearly relates to the intended performance effects. This is always the case when the subject's own performance process is coordinated with an external event. In the case of a racquet game it would demand the temporal coordination of the movement with the approaching ball. This temporal demand can also be mentally practised. It is, in comparison with the above discussed temporal aspects, the more complex case, and can include it.

A further characteristic of kinesthetic imageries is to be included in the framework of the cognitive hypothesis, even though intuitively one would probably place it more with the programming hypothesis. Movement imageries are often combined with motor feelings or kinesthetic sensations. In many mental training concepts these sensations are seen as very important. First of all it should be noted that these sensations cannot be the expression of peripheral muscle activities during kinesthetic imagery, as the body is not moving, and the muscles only rudimentarily so (Heuer, 1985, p. 196). In addition many kinesthetic sensations are produced not through the active production of movement, but through the reactive forces in the movement process. This viewpoint can be made clear through the luge.

The passage through a steep curve at over 100 kph is connected with certain motor sensations that are based on tactile, kinesthetic, vestibular and somatosensory information, but are not the expression of the production of the movement. This would more likely be the case with a weightlifter who has to lift a heavy weight.

The individual sensory impressions are not individually represented but are collected as a whole and emotionally labelled. They are associated with symbolic and spatial images. The strength of the association, that is the probability of the «reviving» of such movement sensations, depends on the self participation of the person under mental training.

Individual preconditions for effective mental training

The Significance of Imagery Competences

A starting point of the following considerations was the finding that the general effectiveness and efficiency of mental training is not as high as one would expect from theoretical considerations. Two methodological and pratical reasons are given. First, most studies must prove additional effects of mental training, which is made more difficult by the use of naive, uninstructed visualizing strategies in the control groups (e.g., Hall, Rodgers & Barr, 1990; Mahoney, Gabriel & Perkins, 1987). Further it can be assumed that in groups using mental training as well as those using naïve visualizing strategies different individual preconditions for dealing with the envisaging of the own movement exist in either case.

In studies on imagery ability up to 10% of the subjects report that they are unable to form pictorial images (Richardson, 1969). But even in those cases where imagery and movement imageries were produced these show in part strong differences in clarity and details. A further problem area concerns disturbances in the imagery process. Examples are «getting hung up» in the process, skipping, or the constant repitition of segments, the unintentional inclusion of mistakes or the «jumping» into other imagery contents (Eberspächer, 1990). These problems, but also the case of vivid controlled motor images, are based on individual competences that are labelled as *imagery ability*. Such capacities should be modifiable to a certain degree. In addition the exercise, area-specifically accentuated in certain fields of application must be taken into consideration. Thus from now on we should use the term «*imagery competence*» rather than ability.

When one wishes to differentiate between different components of the imagery competence, one can do this in one step with regards to the corresponding perception modality. In motor imagery this concerns the mainly spatial (visual) and kinesthetic (including tactile and somatosensory) images. Auditory perception and imagery processes are often not taken into consideration, unjustly as studies in the field of rowing show (Lippens, 1993). An ad-

vantage of this sensory and imagery modality lies in the capability for representation of important temporal characteristics of the movement process.

In addition to the differentiation by sensory modalities, further characteristics are crystallized out of the descriptions of the imagery contents and forms, with which individual preferences especially for the visual imageries can be differentiated. Thus the following differentiations can be made:

(1) Preferred sensory modality:

First one has to ask about the sensory specific focal point of the motor imagery. In principle imageries can be based on multiple sensory modalities. It is at least possible to record which imagery modalities occur and on what the person's attention is focused.

(2) Vividness of the imagery:

This concerns questions of the degree of differentiation and the intensity of the images. One difference between experiencing and imagining is the fact that images are «paler» and contain fewer details. But the images themselves can be differentiated from each other with regards to these characteristics (a special case of particularly vivid «images» is represented by hallucinations). The vividness of motor images is dependent in addition on self-participation: one imagines oneself or another person carrying out a movement.

(3) The perspectives of visual images:

One differentiates here between the internal and external view of the visual images. The question of whether the attention is focussed on muscle sensation or similar does not concern the internal view but the preferred sensory modality. Whether stronger kinesthetic sensations and possibly stronger ideomotoric phenomena are connected with the (visual) internal view remains to date, an inadequately solved problem.

(4) Control of the imagery:

The poles of this dimension represent the purposeful calling up of images and the passive, involuntary formation of images. This includes a formal-temporal aspect, that is whether one can create a certain image *now* and the aspect of the contents, whether they are the chosen images.

(5) The ability to change the imagery:

Here one can differentiate to what extent a person can change an image once it has been updated and whether the altered images can include new, up until then not «experienced» components. In this sense images can be classified as reproductive or as creative-productive.

These differentiations of individual characteristics of imagery competences make clear that the differentiation into good versus bad visualisers (better imagers) can only depict the whole range of individual characteristics very coarsely. High imagery competences are as a rule characterised by the

great vividness and temporal exactness of the images. A high degree of control is often also present. One has to judge critically the question of whether the relation to the learning performance is a linear one. It is possible that there could be an optimum imagery vividness which lies below a maximally detailed exact reproduction of the imagery. Such questions have not yet been examined for the field of mental training. But in the field of "medium supported model learning" there exist comparable studies that support to the effect that the presentation of conturograms can have advantages over real- or stick-diagrams (Daugs, Blischke, Olivier & Marschall, 1989). This is an indication that it depends on the essential structural characteristics of the motor process. Thus some instructions for mental training refer especially to «critical points» of the movement process (Eberspächer, 1990).

The cardinal point for the differentiation into good and bad imagers is based on the description of the phenomena of the imagery processes. There are also indications from neurological investigations as to different processes in persons with higher or lower imagery competence (Pauls, 1994; Rösler, Heil, Pauls, Bajric & Hennighausen, 1994). These results are based on investigations of slow-event related brain potentials during imagery. Generally it can be observed that the strength of the potentials corresponds with the difficulty of the imagery task and the length of potentials corresponds with processing time. The peculiarity of the differential differences expresses itself in the sense that with weaker imaging ability the potentials (in left hemisphere leads) become stronger. The interpretation of this is that in persons with weaker imagery capability the cognitive effort is greater.

Recording Of Individual Imagery Competences

In the following text we shall specifically discuss the employment of self assessment scales for the recording of individual competence. This choice is justified by the fact that the imagery literature confines itself especially into this inventory method. One has to differentiate – also in the area of motor learning – whether general or movement specific imagery processes are being examined.

The most widespread test for the recording of imagery capacity is the Betts Test. It is mainly used in a shortened form (Richardson, 1969). The test includes the self assessment of the vividness of imageries in different perception modalities. Included are items that include the imagination of daily activities. A second often used test is the «Vividness of Visual Imagery Questionnaire» (VVIQ) by Marks (1989). The items are limited to the visual ima-

gery modality. The most well known test for the controllability of image production is the «Gordon Test of Visual Imagery Control» (Gordon Test) (Richardson, 1969). It includes self assessments for the ability to manipulate the visual imagery processes. Analyses of the theoretical quality criteria showed themselves satisfactorally reliable. In addition to this it can be seen that the dimensions of the vividness and the controllability of the images which as such are thought to be independent are relatively strongly correlated (White, Sheehan & Ashton, 1977).

The «Vividness of Movement Imagery Questionnaire» (VMIQ) was developed as a movement specific parallel instrument to the VVIQ (Isaac, Marks & Russell, 1986). Everyday activities such as «kicking a ball into the air» or «running upstairs» have to be imagined, and scaled as to their vividness. The scores in the movement specific variant (VMIQ) correlate very strongly with those of the general variants (VVIQ). As this correlation is higher than the retest stability of the single tests it does not seem to make sense to assume different imagery dimensions.

The most common test for the recording of movement imagery ability is the «Movement Imagery Questionnaire» (MIQ) (Hall, Pongrac & Buckholz, 1985). The procedure with this test is based on the fact that the test person *carries out* exactly defined movements, and directly after this imagines the movement. The ease with which an imagery picture (visual dimension) and a movement sensation (kinestetic dimension) can be called up is evaluated alternately. In contrast to the VMIQ not the vividness of the image itself but the production of the image is scaled. In case the test person should actually follow the finer points of the instruction, one should rather measure the control of the images than their vividness. The two sub-scales have a correlation r=.58, so that one may assume that different characteristics are actually measured. Connections to the general imagery tests do not seem to have been examined yet .

The question arises as to whether the hopes which have been placed on the relevent imagery tests are realistic. Aspects of the self assessment scales are often problematic. A general counterargument is that they are too unspecific to discover correlations with specific tasks (McKelvie, 1993). Whether the movement specific test represents a solution must be shown by further research; the problem is that everyday items but not sport related items were included. A further (counter-) argument is that specific logical task analyses are lacking (Kihlstrom, Glisky, Peterson, Harvey & Rose, 1991); this concerns the imagery instructions and the choice of the individual items. A third problem that applies not only for general but also for movement specific imagery tests (based on own unpublished data) is characterised in the test theoretical sense as «low task difficulty»: the test does not differentiate sufficiently between the different persons. It only happens in a very small fraction that images are rated as «unclear» or «very unclear».

What consequences can be drawn from these methodological problems? The basic idea of the self assessment scales is based on fact that they are more directly or more strongly connected with the imagery concept than so called «objective» tests (Hall, Pongrac & Buckolz, 1985, p. 109). If one wishes to use these advantages one must record more exactly the internal standards (Kaufmann, 1981; McKelvie, 1993) and the experientially established processes. These self assessment data must therefore be more exactly supported through questionnaire data, then more exact results as to the individual preconditions for movement imagery will result.

Skill and Imagery Competence

A question which is important in theoretical and also in practical respects concerns the connection between the skill level and the type of the imagery processes. It applies to the differentiation among experts and novices and also among successful and less successful athletes.

Against the background of critical comments about the methods for the recording of imagery competence it may be within the bounds of expectation that one finds no corresponding differences in the imagery processes. In a study of female dancers (Overby, 1990) expertise differences in the registration of the «body image» and the registration of the spatial imagery capacity were shown, but not in the vividness of visual and kinesthetic movement imageries. In a study by Williams and Isaac (1991) it was shown that the skill level did not correspond with differences in the imagery competence. In this study with juveniles it was additionally demonstrated that the self assessment scales showed a close correlation between movement-nonspecific and movement-specific images. The authors report however that this connection is absent in elite athletes (Isaac, 1991, cited in Williams & Isaac, 1991). This is an indication that the competences for the actualisation of movement specific imagery are only uncoupled from the general imagery competence as a consequence of the attainment of expertise.

In addition to the different individual preconditions, the different types of image generation are above all of interest in the following. Here one encounters anew the problem of internal versus external perspectives. Experts distinguish themselves by the fact that they are more likely to be able to take in *both* perspectives (Hall, Rodgers & Barr, 1990). They thus do not necessarily prefer the inner perspective but are able to control and change

the perspectives more strongly than beginners. Beginners seem to possess these potentials in a much smaller degree. Here it also depends on what one understands under «internal perspective». If kinesthetic sensations are meant, the difference between beginners and experts is almost trivial (Mumford & Hall, 1985). Whether these differences really relate to the «visual» perspectives remains to be investigated.

If one follows the expertise concept, experts should not be distinguished by special general abilities, but by area specific competences. Imagery competences from the narrower field of expertise should be compared with more unaccustomed movements.

Consequences For The Improvement Of Imagery Competence And The Efficacy Of Mental Training

Images in general and movement images in particular are reconstructed on the basis of meaningful memory components. We are concerned with performance and situation images. This is even true for the images of closed skills. Thus the pictorial imaginations of a gymnastic movement contain at least single features of the gymnastic apparatus. This becomes clearer with movements which have to be coordinated with a moving object (Paivio, 1985; Hall, Buckolz & Fishburne, 1992).

If one follows the concept of mental training as situation anticipation, various situation constellations should be «played through» during the training process. This concerns focussing on individual components of the situation, that is person, environment and task. The pictorial self imagination of the movement process thus covers only one facet of the spectrum.

In the framework of the new learning of movements an exchange of the imagined person (from model to oneself) can be undertaken. In addition, especially in the so called «open» sport disciplines, different starting and goal conditions can be varied in the framework of the imagery. In this way the learning of regular relationships between starting conditions performance and performance results can be supported.

One deficiency in the studies of mental training is that they do not concern themselves enough with the content and the process characteristics of the movement imagery. This problem is all the more important as one can expect relatively large differences with different types of task and on the basis of different personal characteristics, regarding the type and content of the imagery process. As a consequence one must examine in depth the qualitative and quantitative process characteristics of the movement imagery.

This means in principle an accentuation of the phenomenal approach without disputing the fundamental correctness of other approaches. One step in the right direction appears to be the recording of inter- individual differences in the imagery capacity in the framework of the imagery approach. Nevertheless this approach breaks down half way. There are two reasons for this. First an access through the subjective experience of the person is chosen. However it is implied through the employment of standardised scales that well defined constructs are being examined. We have previously presented these argument, in this, one overlooks, the fact that behind characteristics such as «internal view» or «vividness of the image» lie different processes of each subject's experiences. In addition the movement specific items of the scales usually refer to everyday movements, so that individual styles in the imagery process can only be represented to a very limited extent.

This leads to a further problem area, the generality, or alternatively the specificity, of imagery competence. The basic assumptions of imagery research assume the general and relative stability of imagery capacity. The concepts that apply this approach to the motor area assume that abilities related to movement imageries tend to exist which should also be easier to change and to train (Hall, Pongrac & Buckolz, 1985). Even this concept seems still too broadly conceived. With the available instrumentation, area specific competences, such as one would expect as a result of the expertise concepts, cannot be recorded from the start. It is relatively implausible to expect, as a consequence of area specific movement experiences, considerable changes in area non-specific movement imagery.

The consideration of individual peculiarities in imagery processes and competences should also give the research on mental training a new impulse. One consequence could be, on the basis of the recording of deficits, to put training processes for the improvement of imagery competence ahead of the actual mental training. A second strategy could be to examine the effect of various types of imagery instruction under varying imagery preconditions. Such effects are already long known in the pedagogic psychology as «treatment aptitude interaction». This could be a starting point for research on mental training.

From a practical point of view one should be concerned with the combination of mental training with other training forms. One approach which can be transferred from the field of feedback research, is the employment of self-evaluation procedures (Swinnen, 1990). It is assumed that the notion to evaluate one's own movement performance before an external feedback improves learning. The comparison between expected and actual movement indicated through self-evaluation should also have an effect on the quality of the movement imagery during mental training. In this way the status of the

movement imagery also changes. Mental training is then no longer based on an updating of the actual value, but includes stronger imagery competence of the expected value. Through the notion to employ conscious and reflexive processes in mental training, changes are to be primarily expected which are described in the framework of the cognitive hypothesis.

A general characteristic of the inclusion of self-evaluation procedures is the fact that verbal processes are added to the visual processes. In some concepts of mental training they are systematically used, by for instance (internally) verbalizing key points of the movement (Eberspächer, 1990). Practical experience shows that images can be called up and structured more easily in this way. In the sense of the differentiation of individual characteristics of imagery competences verbal processes, the *control* and *alterability* of movement images can be influenced through verbal processes. A specific area, for which the inclusion of the self-instructions for the structuring of the imagery and the movement process suggests itself, is the movement rhythm. With the help of verbal processes one can influence the temporal dynamic structure of the movement process.

In conclusion one further practical problem should be addressed which is discussed in the theoretical context for the explanation of movement imageries as well as in the description of individual differences of relevant imagery competences. Neither in the theoretical nor in the practical perspective can it be substantiated why the internal perspective should be especially important in mental training. From the research area of the imagery approach there are results which show that with experts it depends on the alternation between the two perspectives rather than on the special accentuation of the internal perspective. One should therefore enquire more closely as to the function of such mental training forms. A spatial visual imagery relating to the visual perception of the actor is advisable when the movement task consists of coordinating the movement process with external occurrences (e.g. the movements of an opponent and an oncoming ball). In closed skills, for example gymnastics, an external perspective should then be more effective when it is combined with activity-accompanying verbal cues. Also the concept of the internal perspective which refers to the actualization of movement sensations is to be differentiated with regard to its function. In the discussion of the Carpenter Effect we already pointed out that the movement sensations can only be based to a very limited extent on feedback from the muscles during imagery. Generally one can depict the temporal dynamic process of movements through such kinesthetic images. This could rather be relevant on a middle learning level and in the relearning of movement processes.

Recent developments in this field rely to some degree on speculation. A recommended starting point may ne the investigation of the effect of mental training on imagery competencis. This field requires more research in order to meet the concern raised in this article.

REFERENCES

Berbaum, K. & Chung, C.P. (1981). Mueller-Lyer illusion induced by imagination. *Journal of Mental Imagery, 5,* 125-128.

Daugs, R., Blischke, K., Olivier, N. & Marschall, F. (1989). *Beiträge zum visuomotorischen Lernen im Sport (Contributions to visuomotoric learning in sports.).* Schorndorf: Hofmann.

Eberspächer, H. (1990). Mentale Trainings former in der Praxis [Mental training in practice] Oberhaching: sportinform.

Farah, M.J. (1988). Is visual imagery really visual? Overlooked evidence from neuropsychology. *Psychological Review, 95,* 307-317.

Farah, M.J. (1989). The neuropsychology of mental imagery. In F. Boller & J. Grafman (Eds.), *Handbook of neuropsychology.* Vol. 2 (pp. 395-413). Amsterdam: Elsevier.

Feltz, D.L. & Landers, D.M. (1983). The effects of mental practice on motor skill learning and performance: A meta-analysis. *Journal of Sport Psychology, 5,* 25-57.

Feltz, D.L., Landers, D.M. & Becker, B.J. (1988). A revised meta-analysis of the mental practice literature on motor skill learning. In D. Druckman & J. Swets (Eds.), *Enhancing human performance: Issues, theories and techniques* (pp. 1-65). Washington, DC: National Academy Press.

Finke, R.A. & Schmidt, M.J. (1977). Orientation-specific color aftereffects following imagination. *Journal of Experimental Psychology: Human Perception and Performance,* 4, 599-606.

Goldenberg, G. (1987). *Neurologische Grundlagen bildlicher Vorstellungen.* Wien: Springer.

Gyn, G.H. van, Wenger, H.A. & Gaul, C.A. (1990). Imagery as a method of enhancing transfer from training to performance. *Journal of Sport & Exercise Psychology,* 12, 366-375.

Hackfort, D. (1986). *Theorie und Analyse sportbezogener Ängstlichkeit* (Theory and analysis of sport-related trait anxiety). Schorndorf: Hofmann.

Hackfort, D. (1991). Emotion in sport: An action theoretical analysis. In C.D. Spielberger & I. G. Sarason (Eds.), *Stress and emotion* (pp. 65-73). New York: Hemisphere.

Hale, B.D. (1982). The effects of internal and external imagery on muscular and ocular concomitants. *Journal of Sport Psychology, 4,* 379-387.

Hall, C.R., Buckolz, E. & Fishburne, G.J. (1992). Imagery and the acquisition of motor skills. *Canadian Journal of Sport Sciences, 17,* 19-27.

Hall, C.R., Pongrac, J. & Buckolz, E. (1985). The measurement of imagery ability. *Human Movement Science, 4,* 107-118.

Hall, C.R., Rodgers, W.M. & Barr, K.A. (1990). The use of imagery by athletes in selected sports. *The Sport Psychologist, 4,* 1-10.

Harris, D.V. & Robinson, W.J. (1986). The effects of skill level on EMG activity during internal and external imagery. *Journal of Sport Psychology, 8,* 105-111.

Heuer, H. (1985). Wie wirkt mentale Übung (How mental practice is effective)? *Psychologische Rundschau, 34,* 191-200.

Isaac, A. (1991). *Imagery and movement: it's nature and function.* Unpublished doctoral thesis, University of Otago, New Zealand.

Isaac, A., Marks, D.F. & Russell, D.G. (1986). An instrument for assessing imagery of movement: The Vividness of Movement Imagery Questionnaire (VMIQ). *Journal of Mental Imagery, 10* (4), 23-30.

Jeannerod, M. (1994). The representing brain: Neural correlates of motor intention and imagery. *Behavioral and Brain Sciences, 17,* 187-202.

Kaminski, G. (1981). Überlegungen zur Funktion von Handlungstheorien in der Psychologie (Reflections about the function of action theory in psychology). In H. Lenk (Eds), *Handlungstheorien – interdisziplinar, Bd. 3/1* (pp. 93-121). München: Fink.

Kaufmann, G. (1981). What is wrong with imagery questionnaires? *Scandinavian Journal of Psychology, 22,* 59-64.

Kerr, N.H. (1983). The role of vision in «visual imagery» experiments: Evidence from the congenitally blind. *Journal of Experimental Psychology: General, 112,* 265-277.

Kihlstrom, J.F., Glisky, M.L., Peterson, M.A., Harvey, E.M. & Rose, P.M. (1991). Vividness and control of mental imagery: A psychometric analysis. *Journal of Mental Imagery, 15,* 133-142.

Kosslyn, S.M. (1987). Seeing and imagining in the cerebral hemispheres: A computational approach. *Psychological Review, 94,* 148-175.

Lippens, V. (1993). Wenn alles läuft! Zur Modifikation der Subjektiven Theorien von Rennruderern in Training und Wettkampf (In the case everything runs well! Modification of subjective theories of rowers in training and competition) . In V. Lippens (Hrsg.), *Forschungsproblem: Subjektive Theorien. Zur Innensicht in Lern- und Optimierungsprozessen* (Research problem: Subjective theories. The inner perspective in processes of optimization) (pp. 17-27). Köln: Sport und Buch Strauß.

Mahoney, M.J. & Avener, M. (1977). Psychology of the elite athlete: An exploratory study. *Cognitive Therapy and Research, 1,* 135-141.

Mahoney, M.J., Gabriel, T.J. & Perkins, T.S. (1987). Psychological skills and exceptional athletic performance. *The Sport Psychologist, 1,* 181-199.

Marks, D.F. (1989). Bibliography of research utilizing the Vividness of Visual Imagery Questionnaire. *Perceptual and Motor Skills, 69,* 707-718.

Marmor, G.S. & Zaback, L.A. (1976). Mental rotation by the blind: Does mental rotation depend on visual imagery? *Journal of Experimental Psychology, Human Perception and Performance, 2,* 515-521.

McKelvie, S.J. (1993). Vividness of visual imagery for faces as a predictor of facial recognition memory performance: A revised view. *Perceptual and Motor Skills, 76,* 1083-1088.

Müller, H. (1994). Zur Bedeutung kognitiv-konzeptbildender und motorisch-adaptiver Teilprozesse in frühen Phasen sportmotorischen Modellernens (The meaning of cognitive-conceptual and motor-adaptiv processes in early stages of motor modellearning). In D. Alfermann & V. Scheid (Eds), *Psychologische Aspekte von Sport und Bewegung in Prävention und Rehabilitation* [Psychological aspects of sports and movement in prevention and rehabilitation] (pp. 223-229). Köln: bps- Verlag.

Mumford, B. & Hall, C.R. (1985). The effects of internal and external imagery on performing figures in figure skating. *Canadian Journal of Applied Sport Sciences, 10,* 171-177.

Nitsch, J.R. (1986). Zur handlungstheoretischen Grundlegung der Sportpsychologie [Action theoretical foundation of sport psychology]. In H. Gabler, J.R. Nitsch & R. Singer (Eds), *Einfuhrung in die Sportpsychologie. Teil 1: Grundthemen* [Introduction to sport psychology. Part 1 : Fundamental topics] (pp. 188-270). Schorndorf: Hofmann.

Nitsch, J.R. & Hackfort, D. (1981). Streß in Schule und Hochschule – eine handlungspsychologische Funktionsanalyse [Stress in school and university – an actiontheory based functional analysis]. In J.R. Nitsch (Ed.), *Streß – Theorien. Untersuchungen,Maßnahmen* [Stress – Theories, investigations, interventions] (pp. 263-311). Bern: Huber.

Overby, L.Y. (1990). A comparison of novice and experienced dancers' imagery ability. *Journal of Mental Imagery, 14,* 173-184.

Paivio, A. (1985). Cognitive and motivational functions of imagery in human performance. *Canadian Journal of Sport Sciences, 10,* 22S-28S.

Pauls, C.A. (1994). Interindividuelle Differenzen bei räumlichen Vorstellungsprozessen: Evidenzen von langsamen ereigniskorrelierten Hirnrindenpotentialen [Interindividual differences in processes of space imagery: evidences of slow event related brain potentials]. *Paper presented at the 36th. Meeting of texperimental psychologists at the University of Munich.*

Perrig, W.J. (1988). Vorstellungen *und Gedächtnis (Imagery and memory).* Berlin: Springer.

Pickenhain, L. (1976). Die Bedeutung innerer Rückkopplungskreise für den Lernvorgang [The meaning of internal feedback loops for the learning process] (gezeigt am Beispiel des motorischen Lernens). *Zeitschrift für Psychologie, 184,* 551-561.

Prinz, W. (1985). Ideomotorik und Isomorphie [Ideomotoric and isomorphy]. In O. Neumann (Ed), *Perspektiven der Kognitionspy (Perspectives in cognitive psychology)* (pp. 39-62). Berlin: Springer.

Prinz, W. (1991). Über Wahrnehmung und Bewegung [On perception and movement]. *Zeitschrift für Psychologie, Suppl. 11,* 93-104.

Prinz, W. (1994). Motor images are action plans. *Behavioral and Brain Sciences, 17,* 218.

Richardson, A. (1969). *Mental imagery.* London: Routledge & Kegan Paul.

Rösler, F., Heil, M., Pauls, A.C., Bajric, J. & Hennighausen, E. (1994). Individual differences in spatial cognition: evidence from slow-event related brain potentials. In M. Amelang & D. Bartussek (Eds), *Fortschritte der Differentiellen Psychologie und Psychologischen Diagnostik* (S. 115-129). Göttingen: Hogrefe.

Swinnen, S.P. (1990). Interpolated activities during the knowledge-of-results delay and post-knowledge-of-results interval: Effects of performance and learning. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 16,* 692-705.

Ulich, E. (1965). Untersuchungen über sensumotorisches Lernen [Investigations in sensomotor learning]. In H. Heckhausen (Ed), *Bericht über den 24. Kongreß der Deutschen Gesellschaft für Psychologie* (pp. 363-367). Göttingen: Hogrefe.

Vogt, S. (1994). Imagery needs preparation too. *Behavioral and Brain Sciences, 17,* 226-227.

Vogt, S. (1995). On relations between perceiving, imagining, and performing in the learning of cyclical movement sequences. *British Journal of Psychology, 86,* 191-216.

Volpert, W. (1983). *Sensumotorisches Lernen (Sensomotor learning)* (4. Aufl. 14th ed.). Frankfurt a.M.: Fachbuchhandlung fur Psychologie.

Wehner, T., Vogt, S. & Stadler, M. (1984). Task-specific EMG-characteristics during mental training. *Psychological Research, 46,* 389-401.

White, A. & Hardy, L. (1995). Use of different imagery perspectives on the learning and performance of different motor skills. *British Journal of Psychology, 86,* 169-180.

White, K., Sheehan, P.W. & Ashton, R. (1977). Imagery assessment: A survey of self-report measures. *Journal of Mental Imagery, 1,* 145-170.

Wiemann, K. (1975). *Internes Training. ideomotorische Phänomene und neuromuskuläre Koordination* (Inner training, ideomotoric phenomena and neuromuscular coordination). Unveröff. Diss., Johann Wolfgang Goethe Universität zu Frankfurt am Main.

Williams, L.R.T. & Isaac, A.R. (1991). Skill differences associated with movement performance: II. Imagery and kinaesthesis. *Journal of Human Movement Studies, 21,* 129-136.
Wunderli, R. (1978). Psychoregulativ akzentuierte Trainingsmethoden (Training methods with emphasis on psyching processes). *Zeitschrift für Arbeitswissenschaft, 32,* 106-111.

Manuscript submitted May 1998. Accepted for publication October 1998.