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The PETTLEP Approach to Motor Imagery: A Functional Equivalence Model for Sport Psychologists

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This paper supports the contention that the brain stores memories in the form of a central representation that is accessed by both physical preparation and execution and, more importantly, by motor imagery associated with this preparation and execution. Considerable evidence in support of shared central and vegetative structures suggests that sport psychologists should consider more closely aspects of the performer's responses to the physical skill when providing imagery interventions and not rely on "traditional," more clinically orientated, methods of delivery. Many texts provide a schedule of factors and techniques for psychologists, athletes, and coaches to consider but with a limited theoretical explanation of *why* these factors are the crucial concerns. We, therefore, propose an evidence-based, 7-point checklist that includes: physical, environmental, task, timing, learning, emotional, and perspective elements of imagery delivery highlighting the minimum requirement areas in which sport psychologists should monitor the equivalence to the physical task in order to enhance the efficacy of their practice.

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The idea that imaging skill-related movement has beneficial effects on subsequent overt performance is not a new one and sport psychologists are as voracious in proposing new techniques as they are in employing motor imagery. However, in contrast to its ubiquitous use, little has been done in sport psychology to understand the relationship between the motor image and the movement it represents, and the way in which this relationship may be exploited for optimum effect. Our concern with the current state of theory-based imagery application stems from two areas: (a) from consideration of research design and application, and (b) from theoretical weaknesses.

PROBLEMS WITH THE CURRENT POSITION

Hall, Rodgers, and Barr (1990) reported that athletes have little understanding of how to use imagery. They cite as examples the unsystematic way in which imagery is employed and its use primarily in association with competition. However, this may well be an indication of the unsystematic application of contrary research findings from a multitude of methodological design combinations (Goginsky & Collins, 1996; Murphy, 1994; Vealey, 1994) rather than an issue with the athletes' behavior per se. In other words, the dearth of coherent and empirically supported advice on optimum usage may well determine the behavior problems observed. Hinshaw (1991) supports this criticism through her statements on single variable, outcome-oriented research rather than the identification and examination of underlying processes. "As the complex patterns of interrelated variables emerge, attempts must be made for their coordination with relevant physiological and theoretical mechanisms" (Hinshaw, 1991, p. 26).

We are in agreement with Perry and Morris (1995) who state that, aside from Lang's (1977, 1979) bio-informational theory of emotional imagery, none of the theories common in the sport psychology literature have been subjected to rigorous study and therefore do not represent comprehensive theories based on underlying mechanisms. Is it any wonder then that imagery usage can appear to be inconsistent and slipshod? What we will present, therefore, is an approach based on fundamental cognitive neuropsychology in an attempt to provide a better understanding of the mechanisms involved in motor imagery. Through this consideration, techniques will be proffered which may offer a more effective exploitation of this theory. The paper will propose that, while motor imagery's effectiveness in improving

performance is clearly multifarious, many of these factors seem to have fundamental links to the physical task when imagery is successful. Consequently, the theoretical stance taken in this paper may both support and contradict common practice, but will hopefully also provide an applied perspective for imagery research in the future.

A NEUROSCIENTIFIC APPROACH TO MOTOR IMAGERY IN SPORT

The cognitive neuroscience research is drawn from two main areas of study. The first relates to central and peripheral function during the cognitive steps to action: a preparation phase of intending (cf. Loze, Collins, & Shaw, 1999), planning and programming, and an execution phase (the term motor preparation and execution will be used to describe the cognitive processes which precede and control movement during autonomous overt performance). The second, research considering the central and peripheral topology and typology of motor imagery. We define motor imagery as a force-generating representation of the self in action from a first person (internal) perspective (Jeannerod, 1997). The primary representational sense is kinesthesia. However, because any imagined movement and associated actions will take place in imagined space, there will usually be some associated imagery in other sensory modalities, most notably visual. The perspective/sensory mode issue will be considered in more detail later.

Fundamentally, if, as this paper will support, motor imagery and motor preparation and execution are related to the same motor representation system (Decety & Grèzes, 1999), then consideration of the two processes and the extent to which they covary (their functional equivalence), is vital if motor imagery is to be optimally used as a successful tool in sport psychology (see Jeannerod, 1999, for a comprehensive review of such issues). The fundamental point for applied sport psychology is that, if physical and mental practice are equivalent, then many of the procedures shown to be efficacious in physical practice should also be applied in mental practice as well.

Of course, by their very nature motor preparation/execution and motor imagery will have some differences. The former normally leads to non-consciously controlled, coordinated overt performance. The latter usually has full efference consciously blocked or largely suppressed at some level of the cortico-spinal flow such that overt behavior, if present at all, is minimal and random (cf. Lang, 1979). Similarly, Goldberg (1987, 1992) has

described a dual premotor system with the lateral pathways controlling action that is environmentally based and the medial system involved in the control of memory generated, temporally ordered information, which is arguably a motor image. Therefore, under current Jeannerodian definitions, when motor preparation in the pre-execution stage becomes a conscious process it automatically becomes a motor image of the same action, but is still part of the same motor representation. Strong support for this contention comes from deafferentation and amputee studies where action can be prepared but not executed. For example, Decety and Boisson (1990) have investigated temporal organization of actual and mentally executed graphic movement in hemiplegic patients compared to paraplegic and tetraplegic patients. The brain-injured hemiplegic patients displayed significantly slower mental duration time for the paralyzed compared to the healthy represented limb. However, mental movement times in the spinal injured paraplegic and tetraplegic patients were no different to those of normal subjects. Conceivably, the high level motor processes, presumably sited cortically, of motor preparation and execution, interact with the representation for motor imagery and covariance is only reduced when cortical areas are disrupted.

CENTRAL AND PERIPHERAL FUNCTIONAL EQUIVALENCE

Central Indices

Considerable evidence in support of the functional equivalence issue is provided by analysis of the neural mechanisms active during the two processes. The technique of following cerebral metabolism by regional cerebral blood flow after injection of positron-emitting radiotracers (e.g., ^{133}Xe -non) has highlighted the motor imagery/motor preparation and execution topology. Figure 1 identifies a number of active brain structures functionally equivalent in motor preparation and execution and motor imagery. Even the primary motor cortex (Pascual-Leone et al., 1995) has been reported to show attenuated activation during motor imagery conditions. A significant proportion of cortical area, therefore, shows a pattern of activity during motor imagery similar to that of actual performance. Specifically, prefrontal areas, supplementary motor area (SMA), cerebellum and basal ganglia have all been shown to be active during motor imagery (e.g., Ingvar & Philipsson, 1977; Decety & Ingvar, 1990; Decety, Sjöholm,

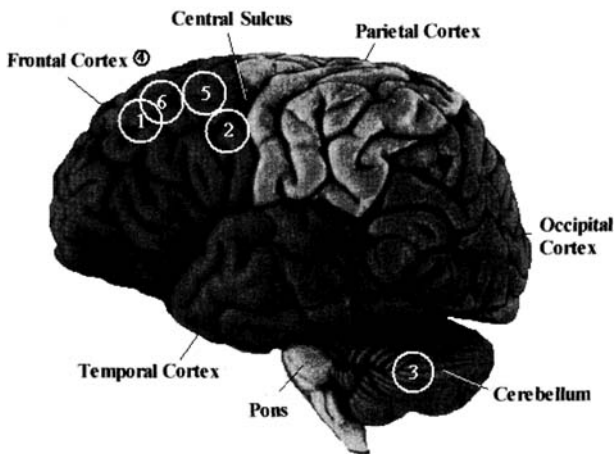


Figure 1. Schematic of functionally active brain regions common to motor preparation and execution and motor imagery: 1 Anterior supplementary motor area and 2 Posterior inferior primary motor cortex (Stephan et al., 1995; Montoya et al., 1998); 3 Cerebellum (Montoya et al., 1998); 4 Frontal lobe (and basal ganglia—not shown) (Decety et al., 1990); 5 Anterior primary motor cortex and 6 Supplementary Motor Area (Deiber et al., 1991; Roland, 1984).

Ryding, Stenberg, & Ingvar, 1990). While motor imagery was found to activate various brain regions, a potentially more significant finding was that brain activity is influenced by the nature of the imaginal task (Jeannerod & Decety, 1995). For example, task requirements have been shown to preferentially recruit different portions of the SMA (Stephan et al., 1995). These and other studies provide strong support for comprehensive consideration of the sport skill being imaged at any given moment in time, matching any attentional “switches” as the skill proceeds, and modifying imagery scripts to consider the effects of learning on the task.

What is clear from this research is that the cortical and subcortical areas active during motor imagery pertain to neural networks known to be involved in at least the early stages of motor control (Decety, 1996b). This supports the argument for common neural mechanisms of motor imagery and motor preparation and execution.

In addition, Beisteiner, Höllinger, Lindinger, Lang, and Berthoz (1995) have shown that there is a common pattern of cortical activation for execution and imagination of a unilateral hand movement. Direct current potential recordings presented no qualitative or quantitative differences between motor preparation and execution and motor imagery over the central sites. Similarly, because motor imagery must involve a sequential organization of action plans (Decety et al., 1990), it is logical to assume that the temporal nature of motor imagery and motor preparation and execution are alike, involving the same neural substrate. A number of studies have shown this to be the case (e.g., Decety, 1996a; Deeke, 1996; Fox, Pardo, Peterson, & Raichle, 1987). Important implications for motor imagery delivery are evident and we will discuss these as part of the proposed model.

Peripheral Indices

In addition to the central measures indicating a close functional equivalence between motor preparation and execution and motor imagery, the peripheral cardiac and respiratory indices which anticipate muscular activity are also increased during motor imagery. For example, Decety, Jeannerod, Germain, and Pastène (1991) showed that heart rate and total ventilation increased proportionally with imagined incremental workloads for treadmill and ergometer exercising, although no overt muscle activity was discernible. Similarly, coupling of motor preparation and cardiac activation has been shown to be evident in both pathologically and experimentally paralyzed subjects (Decety et al., 1990) where the motor preparation can be argued to be more akin to motor imagery since no overt movement was possible. In a study of perspective effects on imagined exercise, Wang and Morgan (1992) demonstrated that ventilation and effort sense were higher when an internal imagery perspective was used. Although there were some similarities between internal and external conditions in metabolic and cardiovascular responses it was concluded that internal (motor) imagery had the greatest resemblance to actual exercise.

Some of the earliest studies considering the physiology of imagery (Jacobson, 1931; Shaw, 1940) found functional equivalence in electromyographic (EMG) activity and while EMG activity has not always been associated with imagery (Yue & Cole, 1992), Jeannerod (1997) has suggested two explanations. First, inhibition of movement may be better in certain subjects or conditions and, second, the preparatory fibers involved have been suggested to be deeper and of the slow tonic type such that usual

surface EMG techniques are unlikely to record this activity. Jeannerod further states that "An incomplete inhibition of motor output (occurring as a consequence of instructions or of a subject's bias) would be a valid explanation for accounting for these muscular discharges" (pp. 110-111). This is a concept very similar to Lang's theory of efferent leakage (Lang, 1979, 1985).

Behavioral Evidence for Functional Equivalence

Obviously, the lack of an overt physical response (even though some "trace" movement can occur) is a problem for research focused on behavioral indices of equivalence. Even here, however, investigation is possible with ingenuity, and studies have used timing to examine the extent of equivalence. The time taken to execute a movement in imagery varies in tandem with temporal (e.g., distance walked; Decety, Jeannerod, & Prablanc, 1989) or complexity parameters (e.g., hand/foot rotation; Parsons, 1987). There are also a wide variety of commonalities between physical and mental practice effects (e.g., contextual interference; Gabriele, Hall, & Lee, 1989), which support the contention that both forms of rehearsal access similar, if not identical, systems and structures. Similarly, Farah (1985) has provided strong evidence that interactions between imagery and perception imply a common locus of activity that consists of representational structures. Her methodologically tight results showed that imagery selectively facilitates perception through recruitment of attention to "the same functionally spatial representational medium in which stimuli are encoded at an early stage of perceptual processing" (Farah, 1985, p. 102).

Further behavioral evidence comes from more qualitative studies. Research that has considered facial gestures has shown that re-experiencing anxious events (visuo-motor imagery) leads to facial movements involved with fear expressions, more facial movement, and increased arousal (Harrigan & O'Connell, 1996).

If behavior is also a functional equivalence element, then sport psychologists may need to consider the congruence of motor imagery behavior to preparation/execution behavior, particularly facial expression (Ekman, 1992), as a possible window on the central and peripheral correlates mentioned above.

Clearly, motor preparation and execution and motor imagery share a number of socio-physiological processes in their occurrence.

IMAGERY AND CONSCIOUSNESS

Recent research demonstrates that motor imagery, and similar processes such as observing a demonstration or watching a video of oneself, produce a selective enhancement of neural activity in motor pathways concerned with the simulated action (Jeannerod, 1999). However, it should be noted that some of the representational levels may not be consciously accessible and, therefore, under current definitions, may not be imaginable (Jeannerod, 1997). Strong support for this contention is provided by research considering the visuo-motor systems. Ungerleider and Mishkin (1982) proposed that visual perception is anatomically distinct from visual control of actions. They identified two functionally different pathways. The first consists of a ventral stream of projections from the primary visual cortex to the inferotemporal cortex that is associated with perceptual identification and recognition of objects. It has associations with higher order brain areas involved with memory. The second is identified by a dorsal stream terminating in the posterior parietal region having connections directly with the motor areas and linked to spatial perception, later modified to sensorimotor transformations by Goodale and Milner (1992).

More recent evidence has also identified a third branch of processing suggesting that the two visual pathways are unlikely to act completely independently of each other although the extent may vary. Recent research by Decety and Grèzes (1999) suggests that the goal of the task may govern stream independence. Functional separation is not observed when there is no explicit aim to the perceptual task, which may be the case with some laboratory-based studies in imagery. However, when perception has a definite goal, functional segregation is more clearly seen in the visual pathways. Such findings provide evidence for the validity of imagery "scripts" with meaning and a definite goal-oriented focus.

Studies of patients with damage to one of the visual systems further highlights the projection's function. For example, visual agnostics with damage to Brodmann's areas 18 and 19 (ventral stream) are unable to recognize or describe familiar objects yet still maintain accurate sensorimotor skills. In contrast, posterior parietal damage leaves the patient with no difficulty in object recognition but with impaired reaching and scaling of grasping. Clearly, an understanding of these separate processing routes has much to offer the sport psychologist. In this regard, Goodale and Milner (1997) have suggested,

[I]nformation can be processed in the dorsal system without reaching consciousness and that this prevents interference with the perceptual constancies intrinsic to many operations within the ventral system that do result in awareness. Intrusions of viewer-centered information could disrupt the continuity of object identities across changing viewpoints and illumination conditions.

If this argument is correct, then there should be occasions when normal subjects are unaware of changes in the visual array to which their motor system is expertly adjusting. (p. 404)

It is plausible, therefore, that elite sport situations may require athletes to process the majority of visual information through the dorsal stream (cf. Decety & Grèzes, 1999; Milner & Goodale, 1995; Shaw, 1996). This explanation appears particularly plausible when one considers self-reports of good performances, because individuals are rarely able to consciously report visual events. Motor imagery scripts of similar events, by their very nature, may primarily direct information processing through the ventral stream for the conscious visual experience. Certain propositional scripts and perspectives may accentuate this somewhat erroneous route. This should be of some concern for the sport psychologist. If, as will be proposed later, the specific task elements of the performance behavior should be considered in imagery, then matching the conscious and nonconscious attentional components may be very important. This argument also challenges the sport psychologist's traditional view of imagery as a completely conscious process but is supported by several prominent researchers in the field (cf. Marks, 1999; Pavió, 1986). However, this commonly held belief in sport psychology has, until recently, resulted in an almost ubiquitous use of verbal imagery scripts. Athletes rarely report a comprehensive conscious, verbal account of good performance in visuomotor terms (in contrast to poor performances!) yet written or verbal imagery scripts continue to direct conscious attention to task relevant cues. Fundamental to the development of the PETTLEP model was the need to address this paradox of the imagery process. This need is also implicit in the theoretical arguments supporting the approach. Consequently, through whichever modality of imagery, the neural process actioned, be they conscious and/or nonconscious, should strengthen the memory trace (those structures responsible for selecting and initiating a movement) of the motor representation by decreasing the variability of movements in a directly similar way to motor preparation and execution.

We have suggested that there is a congruence of psychophysiological processes taking place during preparation for/execution of motor behavior

and mental imagery of that preparation and execution. Consequently, close functional equivalence has been proposed as an important prerequisite for valid and effective mental practice. We will now identify current practice and propose new techniques to address the functional equivalence issue.

CURRENT POSITION STATEMENT

The versatility of motor imagery has allowed it to be used in a variety of sporting situations. Popular undergraduate texts (e.g., Horn, 1992; Morris & Summers, 1995, Weinberg & Gould, 1999) identify numerous uses of imagery which include skill learning, stress management, performance preview and review, confidence imagery, and injury recovery. As we work with more athletes and coaches we become ever more aware of the diversity of possible interventions!

Historically, sport psychologists have delivered imagery scripts in a multitude of guises: from sport psychologist constructed written scripts delivered by audio tape to groups, through to complex, individualized, multisensory, active imagery sessions. There is, however, no available literature which clearly identifies that the content of the imagery modality has been considered in relation to the preparation and execution behavior, or indeed which techniques best create motor preparation and execution/motor imagery functional equivalence for which individuals. If, as suggested by Fournier and MacIntyre (1997), imagery is a pillar of interventions in applied sport psychology, and recognizing the extent of the sport psychologist's capability to command trust, this should be an important process for all sport psychologists.

We suggest that a minimum, seven point functional equivalence checklist should be consulted by sport psychologists in addition to normal considerations for imagery employment. The acronym PETTLEP is proposed.

THE PETTLEP MODEL

The following seven items for sport psychologists to consider have been distinguished for convenience of communication. The model comprises: physical, environment, task, timing, learning, emotion, and perspective. The model draws on the neuroscientific functional equivalence literature previously mentioned and our experiences of the factors that relate to motor imagery script construction. All the PETTLEP components are subsumed by Langian theory because "it is the interaction between training

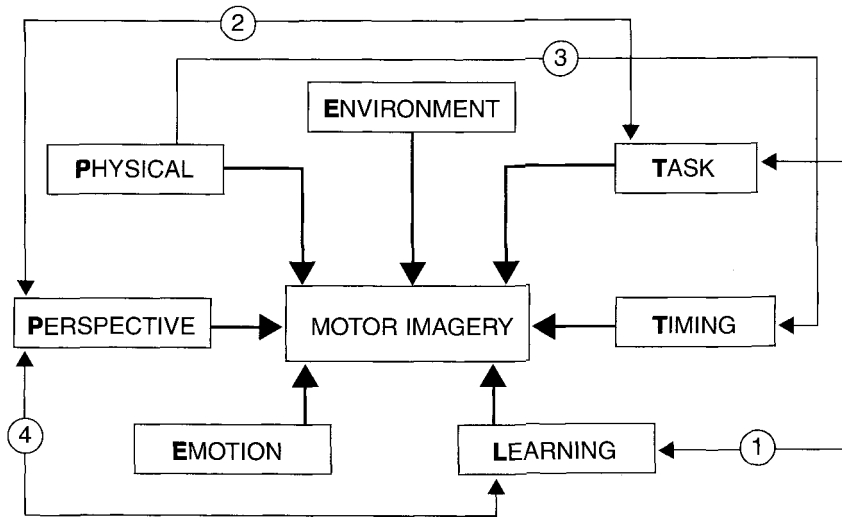


Figure 2. Diagrammatic representation of the PETTLEP model indicating modality interactions and sources. 1 Kontinen et al. (1995); 2 Callow & Hardy (1997); 3 Decety et al. (1989); 4 Collins et al. (1998).

mode and the propositional structure of the imagery presentation that is crucial" (Carroll, Marzillier, & Merian, 1982, p. 76).

The model is not intended to be exclusive and will certainly benefit from comprehensive testing in a variety of settings. However, we believe that many of the alternative arguments for motor imagery's effectiveness can be subsumed within one or more of the model's components. The emotion component, for example, would include affective states associated with confidence as an imagery mediator (Callery & Morris, 1993). Similarly, activation or arousal set (Schmidt, 1982; Vealey & Walter, 1993) would be subsumed within physical, because both attempt to closely match the physiological arousal during motor imagery with that optimal for the task. Imagery, it has been argued, helps direct appropriate attentional focus. The task component serves to address this issue and progresses attentional focus from just task relevant cues to attentive and intensive states (Loze, Holmes, Collins, & Bellamy, 1998). Figure 2 identifies the components and some of the interactions identified in the literature.

Clearly, some interactions are more evident than others, some are only unidirectional, and all interactions will manifest considerable individual differences. While we have highlighted interactions that have been indi-

cated in the literature, the model is far from complete and we would encourage further research to specifically test the implications of the model. For example, modifying the physical nature of the imagery experience will have a direct effect on the arousal level of the performer and, subsequently, the emotional nature of the imagery, and this may be particularly true for the internal visual/kinesthetic imagery perspective, in a very meaningful environment. Therefore, the practitioner should consider all possible interactions when using a PETTLEP approach to imagery.

Physical

Most sport performers encounter their first imagery training sessions with the instructions, "lying or sitting comfortably, visualize . . ." Indeed, some authors (e.g., Miller, 1991; Weinberg, Seabourne, & Jackson, 1981) advocate relaxation strategies prior to imagery to clear the mind of distractions. However, the literature's support for such wide spread use seems at best equivocal and certainly not a critical mediating variable (Murphy, 1994). Relaxation's link with imagery seems to be based in its therapeutic past (e.g., Wolpe, 1958) rather than through empirical support from sport psychology research. Suinn's (1976) visuo-motor behavior rehearsal is a method specifically requiring relaxation prior to imagery. While there is little doubt that some relaxation strategies can have a positive cognitive imagery effect for some individuals, the technique does not take into account the somatic influences of relaxation which would seem to be totally contrary to the somatic state of the performing athlete. The majority of relaxation techniques described are primarily somatic in nature and, therefore, are seen to act primarily on somatic systems (Davidson & Schwartz, 1976). However, if relaxation strategies are to be used then techniques which can best create the "calm mind-aroused body" observed in elite performance (Hooper & Collins, 1999), that is, a cognitive state, should be advocated. There are also important interactions here with the task component of PETTLEP.

If functional equivalence is driving the imagery behavior, then manipulating the physical nature of the imagery to most closely approximate to motor preparation and execution would seem more appropriate. Indeed, Beisteiner et al. (1995) have proposed that stimulation of peripheral receptors associated with task execution and activation of the corticomotorneural system during motor imagery will increase the psychophysiological congruence of motor preparation/motor imagery at the central sites. Because creating a motor image that utilizes a greater number of shared

brain regions is clearly beneficial to the strengthening of the memory trace, performers should be actively involved in the imagery experience, for example, involving sporting implements and making movements as necessary (Holmes, Collins, & Saffery, 2000; Mantle, 1994), with the afferent feedback serving as further reinforcement. We have, therefore, used the term mental simulation with movement (c.f. mental simulation of movement, Jeannerod & Decety, 1995) to describe the imagery experience in athletes. Gould and Damarjian (1996) have offered support for this concept with their notion of dynamic kinesthetic imagery which, they contend, helps athletes to recall more clearly the sensations associated with their performance.

Environment

Lang (1979, 1985) has emphasized that the response and meaning propositions must be relevant to the individual. Motor imagery should, therefore, be personalized through full, multisensory involvement of the performer in the generation of the motor image content. Suggesting environmental "as if" situations that are novel to the performer (e.g., Syer & Connolly, 1987, p. 64) may not be an effective use of mental practice. However, supporting individual motor imagery with videotaped recordings of performance in familiar training and competition environments should more effectively access the correct motor representation. In cases in which performance is to take place at a new venue, every attempt should be made to provide the performer with multisensory environmental cues to increase the validity of the stimulus propositions in the imagery process. These may include video footage, photographs, discussion with previous venue performers et cetera.

Task

Decety et al. (1994) have shown that different portions of the SMA are activated depending on the nature of the task. For example, when the motor imagery requires visually guided movements in the presence of a visual object (an externally driven task), the premotor neurons are more active. With internally driven tasks the ventral and mesial portions of SMA exhibit preferential activity. When considering this information in the light of findings by Konttinen, Lyytinen, and Konttinen (1995) there is strong evidence that imagery techniques should be different for elite compared with pre-elite performers (Figure 2, Route 1). Konttinen and his team iden-

tified that during good performance, elite rifle shooters focus primarily on motor control prior to triggering (internally driven) whereas pre-elite shooters were more concerned with visuo-spatial processing (externally driven). If functional equivalence conditions are to be met, then the content, and possibly the imagery modality for elite versus pre-elite, should be different until the pre-elite, begin to display task characteristics of the elite group. Similarly, Hardy (1997) has provided evidence that task characteristics should determine the primary perspective of the imagery although possibly not at the expense of individual perspective preference (Hall, 1997). In tasks where form is emphasized as important, Callow and Hardy (1997) have suggested that a combination of external visual imagery with kinesthetic imagery will lead to superior performance (Figure 2, Route 2) with the external visual image possessing greater information about the nature of the form. Again, here we see the importance of the integration of knowledge from task, learning, and perspective.

Timing

We have identified that if motor preparation and execution and motor imagery access the same motor representation then the temporal characteristics should be the same. This claim for functional equivalence would seem logical because both types of activity are characterized by a requirement to “reconstruct or generate a temporally extended event on the basis of some form of memory” (Vogt, 1995. p. 193). A number of studies have shown this. Vogt, for example, showed that movement tempo and consistency of relative timing were similar in physical and mental practice conditions. He concluded that performance, observation, and imagery of sequential patterns involves a common process. Similarly, the isochrony principle—in which the tangential velocity of movements is scaled to amplitude—is maintained in both motor execution and motor imagery (see Jeannerod, 1997). In addition, a number of studies (e.g., Decety et al., 1989) have shown that time is represented as a function of force (Figure 2, Route 3) with estimated duration derived from this level of centrally represented force (Jeannerod, 1997). Motor preparation and execution generally includes greater force conditions than typical motor imagery. Therefore, in motor imagery, where external force conditions are not present, athletes will perceive increases in felt force as an increase in movement duration according to their response and meaning propositions. To overcome these potential duration increases, the interaction with the physical element of PETTLEP seems appropriate. Holmes, Collins, and Saffery (2000), for

example, have considered this issue in basketball. In a group of varsity players who imaged the free-throw shot while standing holding a basketball, motor imagery times were significantly closer to actual times compared to subjects who imaged in similar conditions but without the ball. Whilst this congruence could be a function of the tactile elements of the ball, subject debriefing suggested that it was the weight that was most important. Similar results have been obtained by Beak, Davids, and Bennett (1999) who demonstrated the importance of haptic information in the choice of tennis rackets. These findings highlight the need to consider kinetic functional equivalence, through singular or interactional PETTLEP elements, to make more effective use of imagery as an intervention.

Motor imagery training that requires the performer to internally image in slow motion must also be questionable. However, we acknowledge the usefulness of the external visual perspective technique isolation approach (in which with slow motion and freeze frame are utilized for certain specific learning-related tasks—a good example of task-perspective-timing interaction). A recent study by Collins, Morriss, Bellamy, and Hooper (1997) has stressed temporal rhythm, as opposed to achieving key body positions, as a key feature of effective performance. Realistic timing, it is suggested, is, therefore, even more important. In sports where the temporal nature of the task is important, performers frequently refer to it first when doing well, and many athletes identify such response propositions as important for their imagery scripts. One elite field athlete, for example, has identified the temporal rhythm of his run up as critical for optimal performance. As a result his imagery script comprises auditory cues relating to his foot strike in the run-up phase (Backley & Stafford, 1995). Verbal or written scripts would serve to confound the temporal access of the representation. Similar emphasis on the temporal elements of the task are emphasized in the Martin Self-Talk Technique (Martin, 1993). In cases in which the temporal nature of the task is important not only technically, but as a meaning proposition for the athlete, specific reference to the timing element of PETTLEP should be made for memory trace strengthening.

Learning

Because the motor representation and associated responses will change over time as learning takes place, so the content of the motor image must change to accommodate such learning and maintain functional equivalence. Pascual-Leone et al. (1995), by analyzing the motor areas, have shown that

motor imagery of finger movements increased in congruence with motor preparation and execution over a one week period. Therefore, where motor imagery is combined with technical training or in intensive learning phases of a task, regularly reviewing content is essential to retain functional equivalence. Unfortunately, this dynamic approach to imagery delivery is rarely seen in the popular sport psychology texts (e.g., Miller, 1991).

Emotion

Emotion has recently been referred to as “the missing link” in sports performance (Botterill, 1997), while others have observed that “the central core of mental training is emotional” (Loehr, 1997). Similarly, Moritz, Hall, Martin, and Vadocz (1996) found that high sport-confident roller skaters used more mastery and arousal imagery suggesting that emotions are an important imagery mediator. Lang (1985) suggests that the performer’s response, and the meaning he or she attaches to a scenario, must be considered if strengthening of the memory trace is to take place. However, Lang has also stated that during emotional imagery the efferent pattern is even more elaborate. If this is the case, then sport-related imagery may access such a powerful emotional associative memory network that efference is poorly inhibited postcerebellum and is far from random as suggested in Lang’s (1977) earlier work. It is our view that when the other modalities of PETTLEP, along with their integrations, and Langian theory are considered in parallel, the associated emotional affect may be so great that relatively specific efference will result and will show high congruence with overt behavior. Furthermore, motor imagery scripts that create such efference should be encouraged if the earlier guidelines relating to physical are to be followed.

Indeed, some studies have found results contrary to those of Lang. For example, Carroll et al. (1982) showed that cardiovascular propositional scripts elicited generalized psychophysiological changes. However, no comparison was made with the physical task, response proposition scripts were not published and, most importantly, the subjects for the study were drawn from a general university population rather than an elite sporting group. The argument remains untested in the sport domain and research is strongly encouraged.

The affective response to the motor image is best shown through the autonomic system (Decety, 1996a). The heart rate and respiration rate changes that accompany motor preparation and execution reflect alterations

in the energetic state of the performer when faced with psychological challenge (Smith & Collins, 1992) as well as metabolic requirements. These changes should certainly be considered and reflected in the imagery content used to address functional equivalence issues. Specific reference may be made to these physiological modalities and has been encouraged to increase the general physiological response (Carroll et al., 1982). Such fundamental research supports autonomic biased response propositions where cardiorespiratory control is required, for example, target sports (Holmes, 1996). The inclusion of emotion as a motor imagery variable challenges the common practice of preceding imagery with a relaxation session (e.g., Miller, 1991; Weinberg & Gould, 1999, and see earlier physical section). If we recognize that sport is not performed in a hyper-relaxed state, we should also recognize that motor imagery of sport should not be either.

Perspective

As previously suggested, motor imagery is performed from an internal orientation (primarily kinesthesia, but cooccurring with other individual and task specific percepts such as vision and olfaction). It is generally well regarded that this perspective, along with similar response propositional approaches (Lang, 1979, 1985), leads to a greater physiological response during the imagery process (Perry & Morris, 1995; Hale, 1982). As we have previously argued, this should lead to more effective learning and performance outcomes. However, recent findings have led to renewed interest in imagery perspective with some authors (e.g., Hardy & Callow, 1999; White, & Hardy, 1995) proposing the use of external visual imagery as a more effective approach for certain types of form based skills which allow the performer to "see" precise positions and movements (Hardy & Callow, 1999). At first glance this may seem to challenge a functional equivalence approach. So why might the external visual perspective be effective in some circumstances and how can functional equivalence explain such effectiveness? We are in agreement with Hardy's (1997) information-based position, but also suggest that a functional equivalence approach can offer additional support. Lang (1985) has stated that network activations can begin with *any* set of concepts and move within, or between, structural levels. Therefore, external visual imagery may contain sufficient propositional information to access the motor representation and allow neural network strengthening. With advanced performers, for whom a well-developed memory trace exists for a given task, it is plausible that the external visual perspective can access other elements of the representa-

tion at the same time as the visual. It is certainly true that theoretical perspectives, which describe the multimodal, interactional coding of information in memory (Pavio, 1986), cortical cell assemblies (Wickens, Hyland, & Anson, 1994), motor representations (Jeannerod, 1994), parallel distributed processing (Rumelhart & McClelland, 1986), or neural networks (Rosenzweig, 1996), offer a mechanism for this effect. In addition, quasi-random or relatively task specific movement may be discernible in experienced performers who adopt an external visual perspective. This contention is supported by Jeannerod (1997) and offers a theoretical underpinning to advice offered by some researchers (e.g., Hall, 1997). Therefore, we suggest that the perspective debate be further advanced to consider the use of interactional perspectives appropriate for the individual and task. While the kinesthetic/internal visual perspective has been considered within this paper, evidence now exists to support research into the kinesthetic/external visual perspective and possibly others.

Under traditional definitions, it should be remembered that the image is a cognitive production. It therefore follows that processing of response information may initiate associated kinesthetic elements of the motor representations during visual imagery but they cannot be consciously attended to simultaneously with the visual image (cf. Pashler & Johnston, 1998). It is possible that some of the visuo-motor elements experienced during performance are not available for conscious imagery, as discussed previously with regard to dorsal stream processing, but can be accessed via modalities containing sufficient response propositions (e.g., a self-model video). If this is the case, then it is likely that meaningful visual images are able to access the kinesthetic elements of the representation at the nonconscious level with corresponding associated efference. This situation is clearly different to conscious, internally based, kinesthetic imagery. However, both approaches access the same representation and may be equally effective.

An interaction with the PETTLEP learning element provides a further issue for the sport psychologist (Figure 2, Route 4). Collins, Smith, and Hale (1998), researching with highly motivated Karate athletes, suggest that conscious attention to visual *then* kinesthetic factors is the perspective most commonly employed by learners. Because the nature of the learner's representation is still at a relatively embryonic stage, the learner must take in the visual information and then "guesstimate" how that image may feel. Such procedures offer a particular advantage to more cognitive tasks where symbolic learning is key (cf. Feltz & Landers, 1983).

The mono-task perspective nature of attention is well recognized during

successful sport performance imagery (Nideffer, 1976), even with the parallel processing of external visual and kinesthetic information. Therefore, more experienced performers must switch between perspectives to be consciously aware of that modality at any given time. The speed of the switching may be so fast, however, that in anecdotal self-reports athletes may verbalize in a way which suggests an interactional visual perspective with kinesthetic imagery. These concepts, however, should not constrain working definitions or practice in sport psychology. The philosophy provides a very narrow interpretation of motor imagery. We would, therefore, support others (e.g., Paivio, 1986) in stating that motor imagery must be considered to contain both conscious and nonconscious elements of the task because the cooccurring (albeit possibly not temporally) correlates of the image must, under the arguments provided earlier, be related to the same motor representation or conceptual network. We therefore subscribe to Kosslyn's (1994) definition of imagery which describes the term as "the internal representation that is used in information processing" (p. 3).

These suggestions support the use of novel approaches (such as new perspectives) but only on the basis of an understanding of their *modus operandi*.

CONCLUSION

Both research and practice (Collins et al., 1998; Holmes, 1996) has identified a number of techniques employing this PETTLEP approach. Video "step in," emotional word sets and music-facilitated videos, have all been used successfully to support sport performance. The theoretically based arguments presented here support such approaches and provide a sound rationale for practitioners in a way that the plethora of anecdotal athlete evidence cannot. While we feel that the PETTLEP approach has a great deal to offer sport psychologists working with imagery-based interventions, we recognize that little of the applied work has been systematically tested. A number of studies are ongoing at our own institutions but we would commend the PETTLEP approach as a suitable new direction for research in the area.

While we recognize that some colleagues will already adopt aspects of the approach in their work, we have rarely heard of scripts which include PETTLEP modalities (presumably as a result of the arguments given above) or that recognize individualized modality interactions. We continue to experience success with this approach and, as athletes become more cogni-

zant and more demanding of the sport sciences, the logical arguments to support such an approach are normally well received. We recommend the approach to colleagues, together with the inherent need for practical advice which is based in sound theoretical perspectives.

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