Abstract

Investigations into the relative effectiveness of either focusing on movement form (Internal Focus) or movement effects (External Focus) have tended to dominate research on instructional constraints. However, rather than adopting a comparative approach to determine which focus of attention is more effective, analysis of the relative efficacy of each specific instruction focus during motor learning could be more relevant for both researchers and practitioners. Theoretical advances in the motor learning literature from a nonlinear dynamics perspective might explain the processes that underlie the effect of different attentional focus instructions. Referencing ideas and concepts from a current motor-learning model, differential effects of either Internal or External focus of instructions are examined. This paper also highlights some deficiencies in extant theory and research design on focus of attention which require further investigations.

Focus of attention and its impact on movement behaviour

Introduction

Researchers in motor learning have investigated the efficacy of instructions based on their focus of attention [1]. Wulf et al. [2, pp 120] described an external focus of attention as "*where the performer's attention is directed to the effect of the action"*, compared to an internal focus of attention, "*where attention is directed to the action itself*". Instructions to learners can be varied by guiding them to focus attention on either the effects of a movement on the environment (i.e., the outcomes of an action) or on body movements (i.e., limb segments) involved in producing an action, respectively. Research has suggested that using an external focus of attention in instructions can help athletes acquire higher levels of skill more quickly (e.g., [1, 2, 3, 4]). While there have been some cursory suggestions as to why an external focus of attention instructions may facilitate performance and learning (e.g., constrained-action hypothesis) [1], a number of questions have arisen concerning the processes by which an internal or external focus of attention might function successfully in the provision of augmented information.

In this study, the potential value of both types of instructions for different individuals and under different task constraints is considered. Relevant concepts related to nonlinear dynamics and the work of Nicolai Bernstein [5] in the motor learning literature are discussed to provide a theoretical explanation for the perceived effectiveness of different foci of attention. The specific aims of this paper are to: a) overview key issues arising from attentional focus studies in relation to the presentation of instructions, b) present a rationale to explain how attentional focus imparted by instructions may operate based on concepts from nonlinear dynamics, and c), discuss practical implications for the use of instructions pertaining to attentional focus in sport.

Key Outcomes of Attentional Foci Research

Experimenters have investigated effects of presenting instructions with different attentional foci in a variety of teaching and learning settings. The typical approach has been to compare the relative efficacy of an internal and external focus of attention, rather than attempting to ascertain what each might contribute to the learning process. For example, Wulf and colleagues [6] investigated participants' responses when learning how to ski on a simulator under internal or external attentional focus conditions. During the learning phase, participants were asked to pay attention to the movement of the feet in the internal focus condition. In the external focus condition, participants were required to pay attention to the motion of the wheels under the ski platform on which they were balancing. A retention test showed that the external focus group demonstrated better performance on the simulator, such as greater sideways amplitude, compared to the internal-focus participants. This observation indicated that external focus of attention instructions had potential benefits in learning. It should be noted that the study by Wulf was just one of many similar investigations on focus of attention by researchers in motor control and motor learning; putative benefits of external focus instructions and feedback have also been documented in golf [7], performing bicep curls [8], tennis [9], basketball [10], baseball [11], volleyball and soccer [12]. See Table 1 for some representative empirical studies undertaken to examine focus of attention.

Insert Table 1 about here

The extant literature is dominated by studies that have tended to compare the relative effects of an internal vs. external focus of attention [1], reporting clear benefits associated with an external focus in terms of improving motor-skill performance and learning [1]. Several theoretical explanations [14, 18] have been proposed to support the perceived benefits of external focus attentional strategies as elucidated below;

Theoretical Explanations for External Focus of Attention Strategies

Common-coding Theory

The Common-coding Theory of Prinz [13] has been proposed as an explanation for the advantages of focusing on effects of one's movements (i.e., external focus of attention). In Prinz's [13] view, perception and action require a common representational medium, with efferent and afferent codes stored in the form of *distal events*. It is assumed that actions will be more effective if planned in terms of intended outcome or effect, rather than in terms of the specific movement patterns produced. Hommel et al. [30] extended the theory and presented it as a Theory of Event Coding (TEC) to emphasise how stimulus and action representations underpinning perception and action are 'coded' and 'stored' in the same manner so that perception and action can readily influence each other.

Constrained Action Hypothesis

Wulf and Prinz [31] proposed that the motor system is constrained when internal attentional foci interfere with the body's natural control processes. Wulf and Weigelt [15] found that when participants were given instructions regarding the most effective movement technique (internal focus) after several days of practice on a ski simulator, performance deterioration was observed. They suggested that providing participants with specific instructions on the best way to perform on the ski simulator task hampered learning in novices. Instructions on movement form did not promote learning as learning was degraded through disruption of inherent automatic movement control processes. In contrast, an external attentional focus seemed to allow the body to regulate relevant body movements automatically. To account for these findings, Wulf et al. [14] proposed a constrained-action hypothesis purporting that when participants utilize an internal attentional focus, they might actually restrict or impede the automatic control processes that would normally control a movement. However, with an external attentional focus, they proposed that the motor system was able to harness inherent self-organization processes (i.e., a system's capacity to use environmental energy to spontaneously achieve stable states of functional organization) to regulate movements with fewer conscious processes [32].

It is not clear from extant research whether an external focus of attention is beneficial for all types of task constraints. It remains to be seen whether some tasks may benefit from the use of internal focus instructions, especially when learners need to display specific movement forms in certain specific performance contexts like dance, ice skating, or diving. Internal focus of attention instructions may also prove efficacious in tasks where the movement form required to produce a distinct outcome is highly stable, (e.g., jumping vertically to maximise height reached). Little evidence exists to support the assumed disruptive impact of internal focus of attention instructions on tasks which emphasise the production of specific movement forms.

Gaps in Existing Research on Attentional Focus

Theoretical Shortcomings

While the Common-coding Theory [13] and Constrained Action Hypothesis [14] have been proposed to explain the differences observed between internal and external attentional focus conditions, further investigation is required. The Common-coding Theory [13] and Constrained Action Hypothesis [14] centre on an established concept in cognitive science: conscious processing of information can disrupt automatic control processes that putatively regulate execution. The emphasis was on an examination of *the relative merits* of an external focus of attention rather than an internal focus of attention (which was assumed not to facilitate automaticity to such an extent). This dualist, comparative approach has precluded researchers from investigating precisely when each type of instructional format might be more efficacious in the learning process [32].

A key weakness is that most previous research in this area has typically failed to address the acquisition of movement coordination [33], leading to an over-emphasis on task outcomes as performance measures [32]. Research needs to establish whether this over-emphasis on task performance outcomes in motor learning has placed an undue emphasis on an external focus of attention and the link with automatic control processes. There is a need to clarify whether an internal focus of attention may benefit the acquisition of movement coordination.

One framework that could yield insights into the relative efficacy of different attentional foci for instructions and feedback is Newell's model of learning [33]. With its emphasis on three stages of learning (Coordination, Control and Skill), the model provides a general framework representing how movement coordination and control are acquired with practice and time. Early in learning (Coordination), novices are challenged to acquire a functional movement pattern, as component relations between relevant parts of the body are assembled. At this stage, learners seek to use the stable movement patterns that are present within their existing preferred coordination tendencies to find movement solutions to specific motor tasks [34]. It should be noted that in Newell's model of learning, the term 'Coordination' should not be confused with the classic definition of coordination by Bernstein [5], which relates to movement control or patterns (used in other sections of this paper).

Performers at the next stage of learning (Control) are able to perform with consistency in changing performance environments [33]. At this stage, performers will better associate higher-order derivatives (e.g. speed of movement, force exerted) involved in movement production to effectively accomplish the task goal [35]. As learning progresses and the laws governing control (i.e., key features of effective movement control) are discovered, the learner begins to assign 'optimal' values to the variables controlling the movement at the skill stage. Skill or optimal organisation is observed when the performer uses the reactive forces from the limb or from the environment to produce the movement [35].

Newell's [33] model of motor learning provides a clear reference framework within which researchers can avoid the inherent bias of a relative comparison of an external and internal foci of attention..It can support investigations into the impact of different attentional foci instructions as a function of skill levels. An internal focus of attention might then be appropriate for novices at the Coordination Stage, which entails assembling a basic, functional coordination pattern from the available movement possibilities offered by the human movement system. Moreover, an internal focus of attention may be more useful to the learner if the performance context emphasises movement form instead of performance outcomes. This proposition is supported by Newell's model of learning that explains how an internal focus of attention can still be relevant for the acquisition of movement skills at an early stage of learning. At the Control Stage, individuals may benefit from an external focus of attention to successfully acquire a basic functional movement.

Newell's [33] model of motor learning aids researchers in distinguishing how different foci of attention may be appropriate for different groups of learners. A related issue concerns whether learning processes in *complete novices* have been studied as opposed to *beginners* or *advanced learners* in a specific sport or physical activity, who may be at the Control Stage. In past research (e.g., [2, 26]), instructions that facilitate external and internal attentional foci have been examined with participants differing in task proficiency. To be considered as complete novices, participants need to be exposed to completely novel tasks (in which their intrinsic dynamics [preferred coordination tendencies] were not shaped by previous experience of observing, thinking about or undertaking even a few trials of an activity), which is a challenge for experimenters.

Although participants in many studies have been categorised as novices, the tasks they performed may not have been novel to them and it is possible that research has been biased in examining learning only in participants at the Control Stage of Newell's [33] model [e.g., 36]). It is unclear how many previous studies examined learning in participants at the Coordination Stage, where participants were complete novices to the task (See Table 1). For example, in Wulf et al. [2], participants were categorized as 'novices' with no prior experience in playing golf. Their task was to hit golf balls towards a small circular target. At the initial stage of the research study, participants were assumed to be novices. However, such an assumption may not hold once the participants are familiar with the task. Moreover, it would be realistic to also assume that the preferred coordination tendencies of participants may have been shaped by ideas of what a golf stroke may look like or by prior experience in playing hockey.

To summarise, the use of novel tasks is needed to minimise the impact of a learner's past experiences on the acquisition of a skill. To verify the novelty of a task, baseline tests should be conducted to ensure that performance on these tasks is suitably low from the onset. Although the use of novel tasks should provide some valuable insights into the effects of instructional constraints on skill acquisition processes, the findings may be difficult to generalise to other movement tasks.

Learners may pass quickly through the Coordination Stage (see [36]), where an internal focus of attention may be beneficial to assemble a functional movement solution. It is plausible that some participants might have moved rapidly to the Control Stage in these studies. In this stage, an external focus of attention might be more functional in their adoption of an acquired coordination pattern. Certain studies (e.g., balancing [14, 23]) would also be unlikely to have included complete novices due to the experience that all individuals have acquired since infancy with balancing and postural control in everyday life. These criticisms suggest that individualised analyses may be more effective in research on focus of attention in learning. The typical use of group-based analyses fails to account for individual rates of progression in movement skill.

The use of Newell's [33] model could provide a useful framework to support a dualist approach in identifying which attentional focus might be most efficacious for motor learning. It would be insightful to determine the impact of an external and internal focus of attention as individual novice progress through the Coordination to the Control and Skilled Stages. For example, a switch of focus conditions could be provided as they progress to the Control Stage. This would determine the relative effectiveness of different attentional foci at different stages of learning.

Issues with research design

(i) 'Purity' of instructions.

One of the key concerns in research on attentional focus relates to the 'purity' of instructions under different conditions [37]. It is important to ensure that participants experience instructions or feedback which provides a solely internal or external focus of attention; an element which has proved hard to distinguish in some studies. To exemplify, in one study of exercise performance, participants were asked to perform a standing vertical jump under different focus of attention conditions [27]. Experimental instructions required participants to focus on different informational sources (the rung of a vertical ladder or participant fingertips). It was unclear whether participants actually complied with specific instructional constraints. Additionally, these constraints may have unintentionally varied between conditions due to the inappropriate instructions provided and the goal of the task. In that particular study, the specific task constraints required all participants to reach and touch a rung, although in the internal focus condition, participants were asked to look at their finger tips. This is undoubtedly challenging for the internal focus participants since the instructions and the task goal confound each other.

To perform this type of interceptive action, one needs ultimately to visually attend to the position of a specific target rung, thereby causing participants to switch attention from fingers to the rung in the internal focus of attention condition. Participants in a control condition were required to reach and touch the furthest rung (necessitating that they fixated on it). Therefore, one cannot rule out the possibility that, in the internal focus and control conditions, participants were switching between different visual information sources (finger tips and rung) in regulating the jump and reach action. These instructional constraints clearly differed with those of the external focus condition which entailed focussing solely on the rung. Moreover, in none of the conditions were participants asked to report what they were attending to. Future investigations may be required to examine the effect of instructional information on movement behaviour and at the same time, the impact of internal and external foci on performance (in the absence of instructions).

(ii) Need for manipulation checks.

The lack of clarity with regards to instructions and the possible switching of attentional foci are serious methodological issues which might in themselves provide the basis for an alternative explanation for the findings. A manipulation check in these experiments would have provided some qualitative data to assess what the participants might have been focusing attention on. Without such manipulation checks, one cannot state with any certainty that participants were adhering to the specific instructional constraints of each condition. Perhaps, the use of questionnaires to determine how and where participants in these studies placed their attentional focus could provide some indication to confirm whether the constraints were effectively presented and adhered to by participants.

(iii) Length of practice time.

Additional concerns exist over the amount of time or number of trials allocated for learning during the intervention phase. For example, several of the studies discussed by Wulf and colleagues [2, 14, 27] examined rather short training periods over a few days. Although effects of attentional focus manipulations have been studied over short periods of time, it is not clear whether skill acquisition effects can be observed over prolonged periods of practice.

(iv) Inclusion of coordination data in movement tasks

Most empirical studies have tended to investigate learning and performance changes based solely on task performance outcomes, such as time in balance, accuracy or error measures. There have been few attempts to examine effects of different attentional focus on acquisition of movement coordination in addition to analysis of performance outcomes. For example, Wulf et al. [27] investigated changes to centre of mass for a vertical jump task as a function of focus of attention. However, no kinematic data were captured to determine whether the jump movement pattern was altered with different attentional instructions. This advance has occurred in other studies of instructional constraints. For instance, Lam et al. [3] examined analogy learning which also uses ideas in external focus of attention (i.e., encouraging learners to be more attuned to perceptual-motor information such as speed, space, time to contact or even direction of relevant movement behaviours within the performance context), to examine the efficacy of learning without explicit instructions on technique. In their study, commendable efforts were made to determine changes in kinematic variables in response to different types of instructions (analogy learning, explicit learning and implicit learning).

Further empirical research is required to examine changes to kinematic and kinetic variables with different attentional foci to understand how coordination of human movement may be altered according to such instructions. If the emphasis was on examining coordination changes, it is plausible that the benefits of internal focus of attention instructions could be reported rather than basing effectiveness solely on performance outcomes. This point is relevant to the earlier discussion about the short duration of interventions in most focus of attention studies. It is possible that performance outcome improvements could take a longer time to surface after observable changes to the coordination of the movement are seen.

(v) Attention shifts and task constraints (Form vs. Effect).

Another important issue for future researchers to consider concerns the value of an internal focus of attention when learning under task constraints that emphasise movement form (e.g., learning ice skating, dance and gymnastic routines) as opposed to the achievement of specific performance outcomes (e.g., passing a ball accurately to a team mate). For example, if attention is focused on the trajectory of a golf ball as opposed to the actual movement pattern of driving the ball, how does this affect movement form? Two studies by Maddox et al. [16] and Wulf et al. [14] have used expert ratings to evaluate movement quality under external versus internal attentional focus conditions and both of these studies reported no differences in movement form.

It is plausible that, under these different task constraints, an internal focus of attention could actually be more effective when the goal of the task is to (re)produce a specific movement pattern or routine. Although extant research has emphasised negative effects on *performance outcomes* of an internal focus of attention, resorting to an internal focus of attention with respect to *acquisition of movement coordination* may not be detrimental. Investigations on the impact of external and internal focus of attention instructions have failed to emphasise the relevance of either type of instructions on the form of the movement in most studies. The impact of task constraints used in these studies is critical and perhaps, the nature of the tasks investigated would likely have an influence on the effectiveness of an external or internal focus or even both at the same time! It is therefore pertinent to fully explore the role of task constraints in how external or internal focus attentional instructions can be effectively presented in a learning context. Perhaps, labelling instructions as either internal or external may be a hindrance in developing an understanding of the relative merits of attentional focus instructions. An important step forward in the literature may be to develop understanding of how the different types of instructions may be directed towards *movement dynamics (i.e. the form of the movement)* and *movement effects (i.e. the outcome of the movement)* in acquiring skill [32].

Theory into Practice: Some Implications for Practitioners

Typically, instructions and feedback provided during training are intended to make a learner more aware of his/her movement coordination under the assumption that this is a necessary precondition for the development of appropriate movement technique. However, this interpretation is contradicted by Bernstein's [5] distinction between the various roles of different levels of the central nervous system (CNS). He proposed four broad levels of control in the construction of movements (see Figure 1). The lowest level of tone (to maintain posture and tone) was followed by the level of synergies (to recruit and link together muscular-articular groups), the level of space (deals with targeted and purposeful movement in the space adjacent to the body) and the level of action (conscious thought and high-level brain control systems for planning and fine motor control). The upper levels of control (level of space and action) are responsible for planning and exercising control and the lower levels (level of tone and synergies) provide the mechanisms for constructing movement.

An important point is that control of movement can be located at any of the levels although the system is proposed as a hierarchy and types of skill as well as differing amounts of practice will influence the role played by each level in controlling movements. Although there is no specific empirical evidence to support Bernstein's ideas on four levels of control, the powerful conceptual framework provides a logical basis for understanding how movement can be controlled [see 38]. An individual acquires dexterity or skill (ability to find a motor solution for any external situation quickly, rationally and resourcefully) when there is functional organization between a higher and lower level of control. Specifically, an optimal division of labour between the higher and lower levels of the system leads to an individual becoming more skilled in the achievement of a task [38].

According to Bernstein [5], with increasing sophistication of performance, responsibility for coordination and control is delegated to subordinate levels of the CNS, allowing learners to harness the self-organising movement-system dynamics that are most functional for the task in question. With an external focus of attention, there is little disruption to the lower levels of control as learners are directing their attention to the effect of the movement rather than to the levels of tone or synergies that are critical for movement form itself.

Insert Figure 1 about here

In designing successful learning experiences, self-organising processes should be exploited and the use of an external focus of attention on movement effects seems to encourage such processes. Nevertheless, the specific role of internal focus of attention instructions, when referenced to Newell's model of learning, may still have a role to play very early in the acquisition of movement coordination or under specific task constraints; these issues require further investigation.

An implication of the ideas raised in this paper concerns the type of feedback provided to learners when they are attempting to acquire a new skill. The aim of providing feedback is to guide learners towards a functional movement form (capturing the goal of the movement task). The teaching goal is usually to maximise performance outcomes such as time in balance or distance or accuracy of a throw. For example, students can be informed of their deviation from the desired goal movement. The nature of such feedback is usually directed at the student's movement coordination pattern. While an external focus of attention may have been suggested as an advantage for learning new skills, novices or complete beginners may require instructions that focus on the establishment of movement form. Such instructions help to build a relationship between the movements of body parts, which is especially relevant at the Coordination stage. However, it should be noted that the movement form may not have to follow the perception of an idealized movement pattern. The acquired movement form at this stage should be individually-specific and also provide some level of success in achieving the task goal. Subsequently, once an approximation of the movement has been acquired, it might prove more functional to present external focus instructions that further emphasise movement outcomes to be produced at the Control stage. It would be worthy to note that the stages of Newell's model of learning are considered to exist in overlapping domains instead of a distinct and hierarchical structure. This description may explain the phenomenon observed when learners receive differential instructions which promote a shift in their attentional focus.

A general recommendation is for practitioners to adopt a facilitative, rather than prescriptive role in the provision of augmented information to learners. The use of instructions might be considered as presenting key task constraints to channel learners to explore functional movement solutions in view of the intrinsic performer constraints, task demands and physical/social environment. For complete beginners, a functional movement solution may not exist and internally focused instructions may be helpful in establishing a basic coordination pattern to be developed in practice. Thus, when learning a forehand drive in tennis at the Coordination stage, the coach could provide very simple cues aligned to analogy learning (see [39]). These cues provide learners with some basic expectations on a functional movement pattern without specifically prescribing the explicit form of the movement. For example, coaches could instruct players to 'Move the racket up a ramp as you contact the ball' when they perform a forehand drive or 'Scratch your back with the racket' when they perform a serve. When such instructions are provided, attention is centred on the movement effect which emphasises requisite relations between the limb segments involved in the basic movement pattern. The inclusion of overly prescriptive instructions like, 'Bend your elbows and move your arm about your shoulder from low to high' could disrupt the use of inherent self-organising processes that support movement control, resulting in poorer performance. Once an approximation of the movement pattern that could be individually-specific is acquired, the coach can then emphasise the presentation of specific external focus instructions such as, ‘pay attention to where you want the ball to land in your opponent’s court’ or ‘watch the dip in the flight of the ball as it goes over the net’.

The focus on the target area or flight of the ball could allow the learner to explore movement solutions without being overloaded with explicit information about a specific movement form which can disrupt exploitation of self-organising processes. These instructions are especially relevant at the Control stage where the emphasis is on adapting movements to meet changing environmental demands (e.g., hitting to different directions, hitting near or far shots). At this stage, the learner is challenged to refine higher order derivatives of the movement such as force, direction and accuracy of action. An expectation, from previous research, is that learners would spend relatively less time at the Coordination stage before moving to the Control stage where varying movement parameters becomes more critical in meeting task goals within the performing context (e.g., [36]).

Research has shown that there is no single formula for the delivery of instructions to learners in all contexts and task. The role of the performer, the task and the environment are all critical interacting constraints (see [40]) that need to be considered during learning and performance. In designing task constraints for learning, practitioners should understand the task objective (e.g., importance of movement form or movement effect) and present appropriate instructions accordingly. Instructions that focus more on movement form could still be pertinent for tasks like dance, gymnastics, ice skating or even weight lifting. Key performer constraints like proficiency level, juxtaposed with a model of learning such as that of Newell [33], can also play an important role in influencing the effectiveness of different attentional focus conditions. There is a need to effectively investigate how and when less or more proficient performers at different stages of learning might find either internal or external focus of attention instructions useful.

Conclusion

This paper has critically evaluated research on the effects of attentional focus in the provision of augmented information during skill learning. While current research on augmented information seems to support the use of an external focus of attention for instructions and feedback, inherent weaknesses in assumptions of relative efficacy of one type of instructional format over another have emerged.

By associating a model of motor learning (e.g., [33]) in the discussion on attentional focus effects, pertinent theoretical issues have been raised for empirical examination. This will determine the effects of either internal or external focus of attentional instructions as a function of skill levels and different task constraints. Previous proposals in the motor learning literature, that external focus of attention instructions are *always* beneficial may need re-examination if complete novices and task constraints are taken into account. The introduction of novel tasks and the use of questionnaires as a form of manipulation check ensure that the instructional intervention is appropriate.

Likewise, it is useful to note that the stages and different levels of learning as referred to by Newell [33] and Bernstein [5] exist as overlapping domains rather than as a framework that is distinct. More empirical work needs to be conducted to carefully examine whether learners alternate between different foci of attention when learning. A research protocol is needed to investigate the interaction of both internal and external focus of attention instructions at various phases of learning (e.g., switch attentional instructions at specific performance milestones) for different individuals. This would account for how different attentional instructions could be effective at different stages of learning.

Theoretical understanding of how various focuses of attentional instructions could work should provide practical implications for teachers and coaches in helping learners acquire skills. Variations in learning processes are both task- and performer-dependent. Practitioners should adopt a facilitative role in guiding learners to search for functional movement solutions regardless of the type of attentional focus presented in various learning contexts.

References

[1] Wulf G. *Attention and motor skill learning*. Champaign, IL: Human Kinetics; 2007.

[2] Wulf G, Lauterbach B, Toole, T. The learning advantages of an external focus of attention in golf. *Res Q Exerc Sport* 1999; 70(2):120-126.

[3] Lam WK, Maxwell JP, Masters RSW. Analogy Versus explicit learning of a modified basketball shooting task: Performance and Kinematic outcomes. *J Sports Sci* 2009; 27(2):179-191.

[4] Poolton J, Maxwell P, Masters W, Raab M. Benefits of an external focus of attention: Common coding or conscious processing, *J Sports Sci* 2006; 24(1):89-99.

[5] Bernstein NA. *The control and regulation of movements*. London: Pergamon Press: 1967.

[6] Wulf G, Höβ M, Prinz W. Instructions for motor learning: Differentiantial effects of internal versus external focus of attention. *J Mot Behav* 1998; 30(2):169-179.

[7] Wulf G, Su J. An external focus of attention enhances golf shot accuracy in beginners and experts. *Res Q Exerc Sport* 2007; 78(4):384-389.

[8] Vance J, Wulf G, Tollner T, McNevin NH, Mercer J. EMG activity as a function of the performer’s focus of attention. *J Mot Behav* 2004; 36:450-459.

[9] Wulf G, McNevin N, Fuchs T, Ritter F, Toole T. Attentional focus in complex motor skill learning. *Res Q Exerc Sport* 2000; 71:229-239.

[10] Zachry T, Wulf G, Mercer J, Bezodis N. Increased movement accuracy and reduced EMG activity as the result of adopting an external focus of attention. *Brain Res Bull* 2005; 67(4):304-309.

[11] Castenada B, Gray R. Effects of focus of attention on baseball batting performance in players of differing skill levels. *J Sport Exerc Psychol* 2007; 29:60-77.

[12] Wulf G, McConnel N, Gartner M, Schwarz A. Enhancing the learning of sport skills through external-focus feedback. *J Mot Behav* 2002; 34(2):171-182.

[13] Prinz W. A common coding approach to perception and action. In: Neumann O, Prinz W, editors. *Relationships between perception and action*. Berlin: Springer; 1990. p. 167–201.

[14] Wulf G, McNevin N, Shea H. The automaticity of complex motor skill learning as a function of attentional focus. *Q J Exp Psychol* 2001; 54A:1143-1154.

[15] Wulf G, Weigelt C. Instructions about physical principals in learning a complex motor skill: To tell or not to tell. *Res Q Exerc Sport* 1997; 68:362-367.

[16] Maddox MD, Wulf G, Wright DL. The effects of an Internal Vs External focus of attention on the learning of a tennis stroke. *J Sport Exerc Psychol* 1999; 21:S78.

[17] McNevin N, Shea H, Wulf G. Increasing the distance of an external focus of attention enhances learning. *Psychological Research* 2003; 67: 22-29.

[18] Wulf G, Shea H, Park H. Attention in motor learning: Preferences for and advantages of an external focus. *Research Quarterly for Exercise and Sport* 2001; 72: 335-344.

[19] Beilock L, Carr H, MacMahon C, Starkes L. When paying attention becomes counterproductive: Impact of divided versus skill-focused attention on novice and experienced performance of sensorimotor skills. *Journal of Experimental Psychology: Applied* 2002; 8: 6-16.

[20] Al-Abood A, Bennet J, Hernandez M, Ashford D, Davids K. Effects of verbal instructions and image size on visual search strategies in basketball free throw shooting. *Journal of Sports Sciences* 2002; 20: 271-278.

[21] Perkins-Ceccato N, Passmore R, Lee D. Effects of focus of attention depend on golfers' skill. *Journal of Sport Sciences* 2003; 21: 593-600.

[22] Totsika V, Wulf G. The influence of external and internal foci of attention on transfer to novel situations and skills. *Research Quarterly for Exercise and Sport* 2003; 74: 220-225.

[23] Wulf G, Mercer J, McNevin NH, Guadagnoli MA. Reciprocal influences of attentional focus on postural and supra-postural task performance. *J Mot Behav* 2004; 36:189-199.

[24] Landers M, Wulf G, Wallmann H, Guadagnoli A. An external focus of attention attenuates balance impairment in Parkinson's disease. *Physiotherapy* 2005; 91: 152-185.

[25] Zachry T. Effects of attentional focus on kinematics and muscle activation patterns as a function of expertise. Master's thesis 2005, University of Nevada, Las Vegas.

[26] Marchant D, Clough PJ, Crawshaw M. The effects of attentional focusing strategies on novice dart throwing performances and their experiences. *Int J of Sport Exerc Psychol* 2007; (5):291-303.

[27] Wulf G, Zachry T, Granados C, Dufek JS. Increases in jump-and-reach height through an external focus of attention. *Int J Sports Sci & Coaching* 2007; 2:275-284.

[28] Wulf G, Töllner T, Shea H. Attentional focus effects as a function of task complexity. *Research Quarterly for Exercise and Sport* 2007; 78: 257-264.

[29] Emanuel M, Jarus T, Bart O. Effect of focus of attention and age on motor acquisition, retention and transfer. *Physical Therapy* 2008; 88: 251-260.

[30] Hommel B, Musseler J, Aschersleben G, Prinz W. The theory of event coding (TEC): A framework for perception and action planning. *Behav Brain Sci* 2001; 24:849-878.

[31] Wulf G, Prinz W. Directing attention to movement effects enhances learning. *Psychon Bull Rev* 2001; 8(4):648-660.

[32] Davids K, Button C, Bennett SJ. *Dynamics of skill acquisition: A constraints-led perspective.* Champaign, IL: Human Kinetics; 2008.

[33] Newell KM. Coordination, control and skill. In: Goodman D, Franks I, Wilberg RB, editors. *Differing perspectives in motor learning, memory, and control.* Amsterdam: North-Holland; 1985. p. 295-317.

[34] Thelen E, Smith LB. A dynamic systems approach to the development of cognition and action. *J Cogn Neurosci* 1995; 7(4):512-514.

[35] Williams AM, Davids K, Williams JG. *Visual perception and action in sport.* London: E & FN Spon; 1999.

[36] Vereijken B, van Emmerik REA, Whiting HTA, Newell KM. Free(z)ing degrees of freedom in skill acquisition. *J Mot Behav* 1992; 24:133-142.

[37] Davids K. Increases in jump-and-reach height through an external focus of attention: A commentary. *Int J Sports Sci & Coaching* 2007; 2(3):285-288.

[38] Beek PJ. Toward a theory of implicit learning in the perceptual-motor domain. *Int J Sport Psychol* 2000; 31:547-554.

[39] Liao CM, Masters RSW. Analogy learning: A means to implicit learning. *J Sports Sci* 2001; 19:307-319.

[40] Newell KM. Constraints on the development of coordination. In: Wade MG, Whiting HTA, editors. *Motor development in children. Aspects of coordination and control.* Dordrecht, Netherlands: Martinus Nijhoff; 1986. p. 341-360.

Table 1. Representative summary of empirical studies on focus of attention.

Researchers	Nature of Study	Movement Task	Assumed Reported Level (Possible Actual Level)	Form/ Outcome
Wulf & Weigelt (1997)	Examination of the effect of attentional focus on balancing task	Ski simulator task	Coordination (Control stage)	Outcome
Wulf, Höβ & Prinz (1998) (Experiment 1)	Examination of the effect of attentional focus on balancing task	Ski simulator task	Coordination (Control stage)	Outcome
Wulf, Höβ & Prinz (1998) (Experiment 2)	Examination of the effect of attentional focus on balancing task with external distractions	Stabilometer	Coordination (Control stage)	Outcome
Maddox, Wulf & Wright (1999)	Examination of external focus instruction in the learning of a tennis skill	Tennis backhand stroke	Coordination (Control stage)	Outcome
Wulf, Lauterbach & Toole (1999)	Examination of the effect of attentional focus on golf chip shots	Golf chip	Coordination (Control stage)	Outcome
McNevin,Shea & Wulf (2003)	Examination of whether an external attentional focus promotes more automatic control processes than an internal focus	Stabilometer and a dual task of pressing a response button	Coordination (Control stage)	Outcome
Wulf, Shea & Park (2001)	Examination of individual preferences as to whether external or internal instructions aids better performance	Stabilometer	Coordination (Control stage)	Outcome
Beilock, Carr, MacMahon & Starkes (2002)	Examination of the effect of skill-focused and dual-focused interventions on golf putting and soccer dribbling	Golf putting and soccer dribbling	Expert golfers at Control stage (Control or Skilled stages) and Novice soccer players at Coordination stage (Control stage)	Outcome
Al-Abood, Bennett, Hernandez, Ashford &	Examination of the effect of attentional focus on Basketball shooting	Shooting accuracy in basketball	Coordination (Control stage)	Outcome

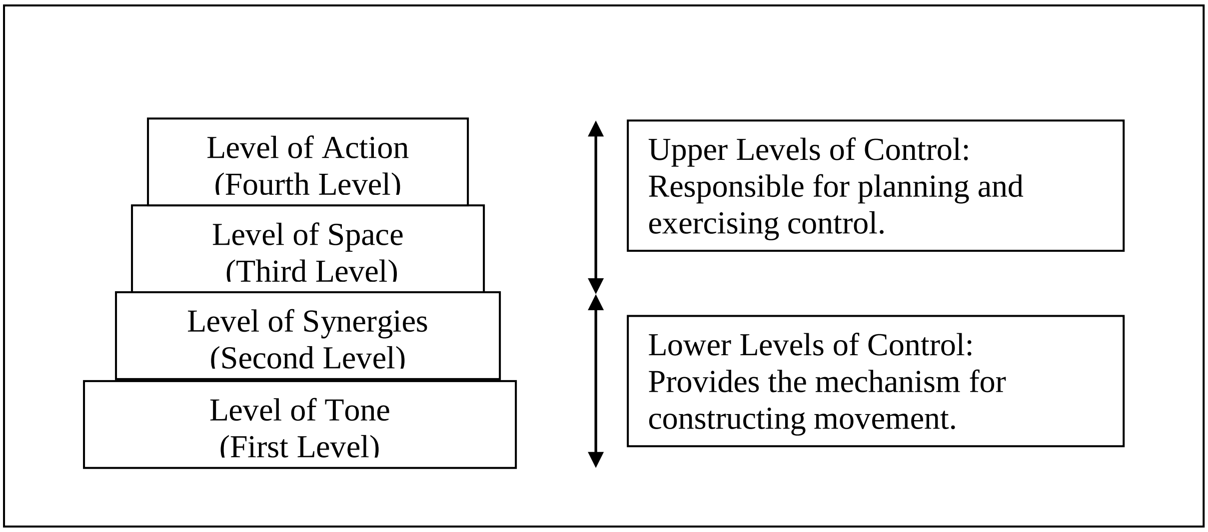
Davids (2002)				
Wulf, McConnel, Gartner & Schwarz (2002)	Examination of feedback effectiveness while inducing external focus of attention rather than internal focus in a sports movement	Volleyball serves	Coordination (Control stage)	Outcome
Perkins-Ceccato, Passmore & Lee (2003)	Examination of performance as a function of attentional focus	Golf	Coordination (Control stage)	Outcome
Totsika & Wulf (2003)	Examination of performance (movement speed) when external focus instruction is given as compared to using internal focus	Pedalo	Coordination (Control stage)	Outcome
Wulf, Mercer, McNevin & Guadagnoli (2004)	Examination of amount of postural sway when individuals standing on the platform focuses externally compared to internally.	Standing still on compliant surfaces	Control (Control stage)	Outcome
Landers, Wulf, Wallmann & Guadagnoli (2005)	Examination of amount of postural sway when individuals standing on the moving platform focuses externally compared to internally.	Standing on a moving platform	Control (Control stage)	Outcome
Zachry, Wulf, Mercer & Bezodis (2005)	Examination of performance as a result of attentional focus.	Shooting accuracy in basketball	Control (Control stage)	Outcome
Zachry (2005)	Examination of effectiveness of internal vs external focus instructions for American football place kicking.	American football place kicking	Coordination (Control stage)	Outcome
Marchant, Clough & Crawshaw (2007)	Examination of performance as a result of attentional focus instructions.	Dart throwing task	Coordination (Control stage)	Outcome
Wulf, Zachry,	Examination of effectiveness	Vertical	Control	Outcome

Granados & Dufek (2007)	of external focus for a motor skill already in the repertoire of adult participants.	Jump and reach task	(Control stage)	
Wulf, Töllner & Shea (2007)	Examination of effectiveness of various focus of attention instructions as a function of task difficulty	Balancing task on different surfaces	Control (Control stage)	Outcome
Emanuel, Jarus & Bart (2008)	Examination of focus of attention for a target task as a function of age	Dart throwing task	Coordination (Control stage)	Outcome

Figure Captions

Figure 1. Adapted schematic illustration of Bernstein's 4 levels of control model (1967).

Figure 1.


Level of Action
(Fourth Level)
Level of Space
(Third Level)
Level of Synergies
(Second Level)
Level of Tone
(First Level)
Upper Levels of Control: Responsible for planning and exercising control.
Lower Levels of Control: Provides the mechanism for constructing movement.