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**IMPLICIT LEARNING PROCESSES INVOLVED IN THE
ACQUISITION OF SENSORIMOTOR SKILLS**

By

Stephen M. Weiss

**A dissertation submitted to the Graduate Faculty in
Psychology in partial fulfillment of the requirements
for the degree of Doctor of Philosophy, The City
University of New York**

2002

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This manuscript has been read and accepted for the Graduate Faculty in Psychology in satisfaction of the dissertation requirement for the degree of Doctor of Philosophy.

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Abstract**IMPLICIT LEARNING PROCESSES INVOLVED IN THE
ACQUISITION OF SENSORIMOTOR SKILLS****by****Stephen Weiss****Advisors: Professor David R. Owen and Professor Arthur S. Reber**

This paper examines the connection between implicit learning systems and sensorimotor systems. Specifically, the effects of different types of focusing strategies on complex motor skill learning were investigated. The current experiment was conducted on indoor basketball courts at two different locations. The participants' task was to shoot a basketball from the "free throw" line located 15 feet from the basket. During an acquisition phase, training consisted of two different focusing strategies that participants could use to accomplish the shooting task. Primarily, participants in the internal-focus group concentrated on their arm angles relative to the upper arm and on the position of their legs and feet while shooting the ball. Participants in the external-focus group focused on something in the external environment or more simply anything that was not considered associated with their body. A novel manipulation included in this design is referred to as the "forced-opposite." During the testing phase, half of the participants were instructed to shoot in the opposite of their previously declared preferred focus. The others were instructed to shoot using their preferred focusing strategy. This procedure produced four testing conditions: (1) "external-focused preferred" group instructed to use

external-focus strategy (EE), (2) “external-focused preferred” group instructed to use internal-focus strategy (EI), (3) “internal-focused preferred” group instructed to use external-focus strategy (IE), and (4) “internal-focused preferred” group instructed to use internal-focus strategy (II).

The statistical analysis utilized was a $2 \times 2 \times 2$ ANOVA with repeated measures on a pretest-posttest factor. This analysis investigated whether a shift in participants' prepost (P) scores had taken place and whether the type of instruction (I) that one was “forced” to use influenced a prepost test shift. The potential shift of prepost scores may also depend on the participants' preferred focus (F). The ANOVA detected a trend for the three-way $P \times I \times F$ interaction; $p = .072$. From this trend, we can see that the $P \times I$ interaction is changing depending on the levels of F.

The data on participants stating a preference for an internal focus found no significant differences. The prepost shift is the same size for both instructed foci when their preferred focus is internal ($P \times I$ at F internal; $p = .735$). Therefore, we are witnessing the same prepost change for the II and IE groups.

The next part of this analysis investigated whether a prepost shift occurred when participants used an internal focus, independent of their instructed focus. In fact, for participants preferring an internal focus (P at F internal) the change in prepost scores was significant $F(1, 96) = 19.001, p < .0005$. The II and IE groups demonstrated a prepost shift. As noted above, this prepost shift is not dependent on instructed focus. These groups display similar improvements in their pre-posttest scores.

The next part of this analysis concerns the influence that an instructed focus might have on prepost scores when participants' preferred focus is external. Selecting the data

on participants stating a preference for an external focus only, there was a significant difference in the size of the prepost shift. $P \times I$ at F external was significant $F(1, 96) = 5.347, p = .023$. The sizes of the prepost change for participants using an internal instructed focus and the prepost change for participants using an external instructed focus are not the same when the preferred focus is external. Specifically, we are seeing different prepost shifts for the EE and EI groups, respectively. The amount of prepost change differs from one instruction to the other.

From this point in the analysis, it is important to find out what takes place on the prepost test when preferred focus is external and the instructed focus is external. There was a significant change in prepost performance scores when participants are put in this condition. P at F external and I external was significant $F(1, 96) = 20.561, p < .0005$. Here, the EE group is showing a change on the prepost test. Finally, when the preferred focus is external and the instructed focus is internal the prepost test shift was not significant (P at F external and I internal; $p = .209$). Here, the EI group is not showing a shift in their prepost scores. Therefore, from a look at these simple simple effects it can be seen that allowing participants to use their preferred focus (EE) produces a shift in pre-posttest scores while those in the “forced-opposite” condition (EI) did not demonstrate any change in their prepost performance. Specifically, EE's scores significantly improved during testing and the EI group's scores stayed the same.

The data indicate that EI was the only group that did not show significant improvement during testing. This finding supports the a priori hypothesis suggesting that an external focus is superior to an internal focus during the performance of complex motor skill activities such as the basketball-shooting task used in this experiment.

Included in the discussion are several theories as to the why the EI group fails to achieve gains comparable to the other three groups. Additionally, insights on the differences between implicit and explicit foci of attention, internal and external foci of attention, awareness and nonawareness strategies, and how interference inherent in motor skill tasks may affect each are examined. The practical implications of how implicit and explicit systems relate to athletic performances are discussed. Recommendations for coaching and sport psychology are provided.

ACKNOWLEDGEMENTS

The past eight years in the Ph.D. psychology program at Brooklyn College has been filled with many hurdles to clear. During this long journey, there have been many people who have been of great assistance to my cause. Although, this space doesn't allow for the mention of everyone, I will try my best to refer to those who have helped me the most.

I would like to gratefully acknowledge the assistance of three hard-working professors who have given me tremendous amounts of help, guidance, and support throughout all these years. First of all, I would like to thank Dr. David Owen. He has always been there for me, extending himself in his usual laid back and selfless manner. He has given me direction yet encouraged me to think for myself and to formulate my own research style. Next, I would like to thank Dr. Arthur Reber, who introduced me to his implicit learning paradigm and persistently suggested that I concentrate my research efforts linking the sensorimotor domain with implicit learning. I'm very happy that he convinced me to do so. His enthusiasm has definitely rubbed off on me and I hope to continue researching this area of psychology for many years. I would also like to thank Dr. Benzion Chanowitz who has also been of tremendous assistance to me over the years. Buzzy always seemed to put a different twist into the analysis of my investigations. His viewpoints always produced a new way to look at things. He has always been ready to help me whenever I called upon him.

On a personal level, I would especially like to thank my mother who preached education to me from an early age. Unfortunately, half way through the journey she left to go to a better place, but certainly I have felt her spirit as a tremendous source of

inspiration. I would like to thank my father for the work ethic he instilled in me at a young age. It definitely helped me to persevere through this ordeal. I would also like to thank my grandmother whose constant “reminders” to earn this degree are very much appreciated.

I will always look back fondly to all my peers who have helped me through some challenging circumstances. Especially, I would like to thank Jeff Repka and Julie Tison who were of much assistance during the early years when course work dominated our lives.

I would like to thank my girlfriend Beth-Ann Indorf who has given much support and understanding over these final difficult months, as I was finishing up my dissertation.

Finally, I would be remiss if I didn't acknowledge my dog Barkley (named after Sir Charles of professional basketball fame). She's been right there (usually laying by my feet while I typed at my computer) since those first days in the program. Thanks for being my “best friend.”

January 2002

S.M.W.

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INTRODUCTION

The Implicit Learning/Sensorimotor Learning Connection

The separate psychological domains of implicit learning and sensorimotor learning appear to have a common core of principles with overlapping qualities. These shared traits include a cognitive element that is likely present in the sensorimotor domain and a motor element that is likely present in the implicit learning domain. The cognitive element that is potentially an aspect of the sensorimotor domain has to do with the cerebral nature demonstrated by many individuals involved in tasks of this type.

Individuals, for the most part, appear to “study” the motor processes involved when asked to perform a sensorimotor operation. Consciously or unconsciously, it appears that individuals are processing knowledge when performing these acts. It is the latter scenario or unconscious-type learning that appears to be manifesting itself as a very real ingredient of the motor domain. It appears that, when performing sensorimotor tasks, individuals will often perform these tasks best when the learning is of an implicit nature.

Currently, there is extensive literature pertaining to implicit learning, a term initially used by Reber (1967). Reber (1993) defined implicit learning as “the acquisition of knowledge that takes place largely independently of conscious attempts to learn and largely in the absence of explicit knowledge about what was acquired” (p. 5). Until the early 1980’s, Reber and his associates were among a relatively small cadre of researchers investigating implicit learning. The focus of the early studies was primarily on the acquisition of complex information without awareness using an artificial-grammar learning procedure. Reber found that individuals become more and more sensitive to constraints of an artificial grammar simply from exposure to exemplary strings of that

grammar. That is, participants in implicit learning studies often performed effectively but seemed unaware of what they had learned. Furthermore, they find it difficult to communicate to others what they very obviously have demonstrated that they know.

There is also widespread literature regarding sensorimotor learning that may be able to add insight into the implicit learning studies. Although, researchers for the most part have limited their investigations to one of these areas or the other, it is suggested here that there are common characteristics involved in both domains. Both fields of study might profit if researchers involved in each domain were to recognize this possible integration and conduct investigations testing the extent of any integration between the two domains. The current beliefs and conceptions that have dominated the literature to date, with a few exceptions to be discussed in this paper, have not acknowledged this possibility.

Most of the research linking implicit learning and motor learning has been carried out fairly recently. Masters (1992) undertook a breakthrough research investigation where participants were required to test their abilities in a golf-putting skill. During a skill acquisition stage, the participants, all who were novices at golf putting, were each instructed to take 100 putts on four consecutive days. One group of participants was put into an explicit learning condition. These individuals were asked to read explicit instructions on how to successfully putt a golf ball. It was impressed upon the subjects that they should read these rules “carefully and follow them as specifically as possible” (p. 347). Participants placed in an implicit learning condition received no instructions on how to putt a golf ball. Instead, these individuals were required to carry out a random letter generation task in parallel with the putting task. Specifically, participants in the

implicit learning group were required to call out a random letter each time an electronic metronome sounded. It was the intention of the researcher to use this secondary task as a means of suppressing any explicit knowledge being gained by the implicit learning group throughout the investigation. It was only during this learning phase that they were required to perform this secondary task. They were not required to continue the verbal generation of random numbers in the testing segment of the experiment. In the initial skill acquisition phase, participants in both conditions performed the complex motor skill of putting in a “no stress” condition. During the testing phase, participants performed under conditions of stress produced by a combination of “evaluation apprehension and financial inducement” (p. 343).

Masters (1992) found evidence to support the hypothesis that implicit learners were less likely to fail under pressure than their explicit counterparts. Failure was operationally defined as performance decrements measured during the test phase (performance under stress) as compared to performance during the skill acquisition phase. Masters suggested that individuals that fail under pressure might be too aware of what they are doing. Often, under pressure, the individual begins to reflect on the fundamentals involved in the execution of the skill. Masters suggested that such conscious awareness arises when the performer is attempting to find the explicit knowledge of the mechanics needed to perform the skill. Unfortunately, it is during this high awareness period, that the incidence of skill breakdown is most likely. Masters hypothesized that “in passing from novice to expert, or unpracticed to practiced, explicit learning can be minimized” (p. 345). Therefore, it appears that as one becomes more experienced in a particular motor

skill, he or she would likely learn to rely less on explicit processes thus resulting in less skill breakdown during these stressful situations.

Often the novice performer is given the most explicit instructions and consequently is the most likely to suffer a breakdown in motor skills. The breakdown occurs because of what Masters referred to as “the reinvestment of conscious processing” (p. 356), which ultimately may cause events not to proceed in accordance with their intentions. Deikman (1969) initially referred to the reinvestment concept when conceptualizing deautomatization as the “undoing of automatization, presumably by reinvesting actions and percepts with attention” (p. 31). Hardy, Mullen, and Jones (1996) also mentioned the possibility that when individuals consciously monitor their actions, they are utilizing or reinvesting in their explicit knowledge base to the point where performance decrements are likely to occur. They hypothesized that the result of the reinvestment could lead to performance regressing “to a conscious level associated with earlier stages of learning” (p. 622). Masters’ (1992) investigation found evidence supporting the hypothesis that the reinvestment of conscious processing would disrupt automatic processing during the performance of a motor skill.

The reinvestment viewpoints of Masters (1992) are consistent with the arguments put forward by Csikszentmihalyi (1990). Csikszentmihalyi outlined some of the problems that individuals sometimes encounter when attempting to process information. One such problem may be the existence of definite limits concerning the amount of information we can process at any one time. Apparently, we can only handle a portion of this information before our thoughts become jumbled. Masters’ “reinvestment of consciousness” views fit comfortably with the “limits to consciousness” views that Csikszentmihalyi professes.

Instead of relying on automatic processes, we rely on processes that are based on the usage of a focused attention. Csikszentmihalyi warns that doing this can lead to processing difficulties because there may be an inability to “hold in focus more information than can be processed simultaneously” (p. 31).

At this point, there is speculation that individuals who maintain an internal focus and are ultimately too aware of the task which they are attempting to execute may perform less effectively than if they had maintained an external focus and were less aware of the actual carrying out of the task. At the very least, it would seem that certain dimensions of a complex motor task should be bypassed if optimal performance levels are to be achieved. This is especially true when an external interference such as pressure is involved. On the other hand, if they are reacting in an automatic manner, skill breakdowns can be avoided. Often people excel during practice sessions but do not perform up to expectations during the actual event. Several reasons may account for the occurrence of an individual's tendency to fail during testing phases as compared to learning or practice phases. Masters (1992) mentioned that the reinvestment of conscious processing might contribute to one's problems during testing sessions. If individuals are taught to consciously control elementary movement patterns, perhaps these techniques either prevent or inhibit these people from achieving their best performance (Masters & Polman, 1996). In addition to reinvestment, it might be argued that often self-awareness will increase when someone is presented with situations that promote increased arousal levels (Fenigstein & Carver, 1978). When faced with stressful circumstances, a person's self-attention may increase thus leading to detriments in their performance.

Hardy et al. (1996) replicated and extended Masters' (1992) study by adding a new implicit learning group to the experiment. This group was required to continue to perform the random letter generation secondary task during stress trials as well as during the learning trials. As mentioned above, Masters (1992) included this secondary task to be performed by the implicit learning group only during learning trials. Hardy et al. (1996) found that both implicit learning groups continued to improve performance even under stress while the explicit learning group did not. To be more specific, both implicit groups made significant improvements despite being subjected to stress (both financial incentives and an audience were used to induce stress), whereas the performance of the explicit group was severely retarded by the stressful situation. The researchers hypothesized that under stress; individuals may try too hard, causing a transfer from "lower order, automatic subsystems to higher order, controlled subsystems" (p. 632). Also, stress may result in thought processes predominating over imagery-based processes leading to detrimental effects on individuals that commonly practice these techniques suggesting that stressors may be more likely to affect one's explicitly oriented articulatory loop than the implicitly oriented visuospatial processes (Borkovec & Inz, 1990).

However, needing to be addressed is Hardy et al.'s (1990) admission of a potential methodological problem regarding this study. It may be that the researchers' financial incentives and audience effect which were intended to produce a stressful situation may instead have only served to increase motivation for some participants. It appears that some individuals thrive under these conditions and may not feel the anxiety that was the intention of the researchers. A similar problem in methodology is present in Masters

(1992) and in Masters, Polman, and Hammond (1993) investigations. Despite the dilemma concerning how the stressful situation can affect individuals differently, it would appear that pressure situations usually produce a greater negative effect for most people. Under these conditions, people who need to rely on knowledge learned from explicit feedback will likely not perform as efficiently on a complex motor task than those who continue using implicit knowledge despite the stress and anxiety that they are experiencing. For the most part, it would appear that for the “average” person, a stressful state is likely to present interference. This interference may cause more difficulties since someone is not performing in an automatic or implicit fashion. If someone is asked to locate explicitly learned information, outside interference such as a stressful condition can lead to potential problems when trying to find this type of learned knowledge.

Lewis and Linder (1997) reported that when pressure to perform a motor skill is increased, individuals commonly perform worse at a golf-putting task than when there was less pressure. To illustrate this effect, they set up an experimental design that induced conditions of low and high pressure. Introductory psychology students participated in the study as partial fulfillment of a course requirement. They were placed in one of two “pressure conditions.” A low pressure group was given no details as to when practice trials had ended and actual performance had begun. A high pressure group was informed that their next ten putts were being tested and that they would receive double the usual experimental credit for participation if their average putt was “less than 5 cm from the target” (p. 940). Linder et al. (1997) also included a distraction manipulation in the design. Participants placed in a distraction condition were required to count backward from 100 by two’s while putting. The others putted without this prerequisite.

Participants exposed to high pressure performed worse than those in the low-pressure condition and distracted participants performed better than their nondistracted counterparts. These findings suggest that too much concentration may have a paradoxical effect during pressure situations. Often, an individual will succumb to the pressures of the situation if they are focusing too much on the correct actions to perform.

Wulf and Schmidt (1997) examined implicit motor learning in a study involving continuous pursuit tracking. Participants in this study practiced a pursuit-tracking task in which a middle segment was repeated across trials. The repeated movement segment was not identical from trial to trial, yet produced a learning benefit over and above that provided by practice on the nonrepeated segments. Interestingly, “increasing the variability (in terms of the absolute amplitude or time scaling) of the middle segment during acquisition facilitated performance on the repeated segment, relative to constant practice” (p. 996). Through post-experimental interviews, it was found that although subjects were unaware of the repeated segment, the repeated segment was performed more accurately.

Moreover, when participants in a variable group were compared with participants in a constant group, the variable group outperformed the constant group during the acquisition, retention, and transfer stages, a finding that suggests that something abstract was learned in the practice of the repeated segment. Participants’ lack of awareness of the repeated segments suggests that the fundamental aspects of the spatial-temporal patterning were learned implicitly. Wulf and Schmidt (1997) proposed that the findings of their motor skill experiment contained parallels to findings from the cognitive domain. Specifically, they mentioned that Reber (1969), in a study involving artificial grammar

learning, found that participants implicitly learned the underlying structure of the grammar, and that this underlying structure could still be used when the surface structure (the vocabulary) was changed. They felt that Reber's surface structure in grammar might be "analogous to the scaled versions in terms of amplitude and overall duration" (p. 1004) in their study.

Internal/External Foci of Attention and Implicit/Explicit Learning Processes

Wulf, Lauterbach, and Toole (1999) examined the learning differences between external and internal focus of attention. The experimenters found that a golf task was learned more effectively when instructions directed novice players to focus their attention on an external object (the golf club) rather than on an internal object (one's arm movements). The benefits were not temporary as they were also seen in a delayed retention test. These gains were observed early during initial practice rounds, leading one to believe that learners need to focus on the intended effect of their movements. It looks as if strategies that incorporate an external focus of attention are more effective in helping the performer to succeed than are strategies that require someone to concentrate on the movements themselves (internal focus).

Many individuals utilize a kind of imagery to help them perform a kind of conscious mental processing. The procedure is effortful or explicit in nature, is often accomplished by forming mental pictures or images, and seems to be a technique used by many to perform sensorimotor tasks. Interestingly, Wulf et al. (1999) appear to indicate that this technique can be used in an implicit way. For example, when they suggested that learners needed to focus on the intended effects of their movements, it seems they may be

implying that the use of imagery could be used to accomplish this. This presents a paradoxical situation since an awareness technique is being used to divert awareness away from oneself. It appears that from an implicit learning standpoint, imagery can be beneficial if it can somehow change an individual's focus from that of an inward or internal focus to a focus towards one's external surroundings.

Hardy et al. (1996) mentioned that the use of imagery may have the effect of enabling individuals to make better use of their implicit knowledge rather than relying on explicit processes. They suggested that imagery might be used by learners "to produce holistic conceptual representations of movements thus encouraging automatic functioning and accelerating the learning process" (p. 634). In a similar manner, they felt that imagery techniques could also be beneficial to elite athletes as a method to help avoid the debilitating effects of anxiety.

Woolfolk, Parrish, and Murphy (1985) conducted an investigation on the use of imagery during a motor skill activity, accuracy in putting a golf ball. They divided participants into a positive imagery group, a negative imagery group, and a control group (that putted without instruction and presumably did not use imagery). The positive imagery group imagined the golf ball going straight into the cup, while the negative imagery group saw the ball missing the cup. Significant differences among all three groups were found. The positive imagery group displayed the greatest improvement; the control group showed less improvement, and the negative imagery group saw their performance drop. Although, the link between imagery and implicit/explicit theories might be considered as controversial, it appears that this effortful use of visualization may have an effect of consciously (explicitly) shifting one's focus away from self and

towards the external environment (possibly leading to implicit learning). Presumably, this will lead the individual to execute the task in a more efficient manner.

An association appears to exist between Masters' studies (implicit vs. explicit learning) with Wolf's studies (internal vs. external focus). Common characteristics are observed in these investigations. Masters (1992) mentioned that often a performer fails when trying to execute a motor skill because of an "inward focus of attention" (p. 343) that relies primarily on the conscious processing of explicit knowledge. Wulf et al. (1999) mentioned the potential hazards of an internal focus and hypothesized that an external focus could be more beneficial when attempting to execute a motor skill. It appears that both researchers agree that an internal focus of attention leads to a disruption of automatic processes. The resulting losses of automaticity will likely lead to less success in completing the motor skill involved, especially if any source of outside interference is present. Masters (1992) mentioned that drawbacks can often result when an individual's excessive thinking about the proper way to execute a skill (inward attention) can lead to "choking" (p. 345) or failing to perform the skill successfully. Baumeister (1984) defined choking under pressure as "a metaphorical expression used to describe the occurrence of inferior performance despite individual striving and situational demands for superior performance" (p. 610).

Similar to Masters' (1992) opinions, Wulf, Shea, and Park (in press) recommended that to perform a skill successfully, one should divert attention away from their own movements (internal focus) and toward the effects that those movements have (external focus) if they are to be successful in executing a particular motor skill. Additionally, Wulf, Hoess, and Prinz (1998) considered the possibility that attempting to

consciously control one's movements can cause interference with automatic motor processes.

The investigation carried out by Wulf et al. (1998) may give additional credibility to a possible connection between internal/external and implicit/explicit research. The researchers focused on the role of attention or awareness, which could be a key to linking the two paradigms. There seems to be a common thread present, as the implicit learning theorists believe that directing one's attention to the existence of rules underlying a task to be learned can actually slow learning. This is especially true when individuals have been informed about the existence of rules but not about their properties (Reber, 1976). Implicit learning theorists hypothesize that unconscious learning processes are often more effective than conscious ones. Unless explicit instructions clearly lead participants to successful performance, interference will likely be present (Reber, Kassin, Lewis, & Cantor, 1980). In a similar way of thinking, internal/external theorists, such as Wulf, call for people to divert attention away from their body and furthermore to be unaware of their own body movements. Additionally, both ideas emphasize automatic processes as an important ingredient in achieving optimal performance.

The evidence from recent studies of Masters and of Wulf in the motor domain appear to parallel the earlier studies of Reber and his colleagues in the cognitive domain. One area of connection stems from the role of instructions in experiments involving artificial grammar learning with an apparent relationship existing between the type of instruction given to participants and their subsequent performance on these cognitive tasks. Many of the early experiments testing implicit learning processes were run under instructional sets in which participants were not informed that the stimuli were structured

or rule defined. Reber (1993) mentioned that in these studies, “the point was to maximize the emergence of implicit learning” (p. 45). In contrast, often when explicit instructions are given to participants, there is an apparent interference effect that seems to cause significant declines in performance (Reber, 1976).

Reber (1993) pointed out that most individuals when solving cognitive problems do not seem to know how they acquire information that ultimately is the basis for their decision-making. Although it is not the case for all cognitive tasks, Reber surmised, “that people do not typically solve problems, make decisions, or reach conclusions” (p. 13) using only conscious processes. Often, individuals do not rely entirely on conscious awarenesses to reach conclusions but rather achieve their successes by using implicit elements. Reber suggested that individuals performing cognitive tasks are most successful when relying on the automatic processes of implicit systems. In the same way, the recent literature linking implicit learning or external foci in the execution of motor skill tasks seems to equate automatic processes and unawareness with success in performing tasks of this nature.

Langer and Imber (1979) reported that repeated practice on cognitive tasks could lead to an overlearning of that task. The researchers recruited participants to perform a coding task involving the translation of English sentences into different languages where every letter was represented by a corresponding number and symbol. The novel task was employed so that the extremes of task experience, no practice and over-practice, could be compared. They concluded that when a person has reached an overlearning level, he or she appears to have the ability to perform the cognitive task without really knowing how

they are performing the task. Apparently, the individual is able to execute this task without having to think about the steps involved in its execution.

In much the same way, it appears that highly skilled performers in the motor domain do not have to think about what they are doing when executing a motor skill (Singer, Lidor, & Cauraugh, 1993). As in cognitive tasks, individuals who have achieved an overlearning status are able to perform motor operations without having to consciously think about the steps involved. Overlearning appears to have an advantageous quality, in that it frees one's limited attention to focus elsewhere while successfully executing the task at hand. Anderson (1982) has taken the same approach to study how declarative knowledge skills become procedural. Skills can become automatic once we have achieved this overlearning status. Anderson uses the example of driving a car to illustrate this. After we have learned to drive a car, we do not have to consciously think about each step involved. This frees our attention and permits us to focus on other effects.

Wulf et al. (in press) conducted a study attempting to determine whether it could be beneficial for someone to concentrate on the effects that their movements have rather than on the movements themselves. Overall, they were trying to determine whether an external or internal focus of attention would lead to better performance. Participants who practiced a stabilometer task (balancing on a wooden platform) were given the option to take an internal focus on their feet or to take an external focus on two markers attached to a board, one in front of each foot. Specifically, the goal was for the participants to remain balanced by keeping a platform horizontal for a maximum of 90 seconds. Before the practice phase, participants were asked to determine whether it would be more effective for them to concentrate on their feet or to concentrate on the markers during the

execution of the skill. Participants were encouraged to try out both strategies and to switch their attention as many times as they deemed necessary during the practice trials.

After two days of practice, the high majority of participants (16 out of 20) involved in this study choose the external option. It appears that there may be something natural or inborn that guides people to keep a focus that is away from their bodies and to direct attention elsewhere. Wulf et al. (in press) found that participants using the external focus strategy achieved a greater degree of success than their internally focused counterparts. Based on the findings of this investigation, they reported that most learners are effective in determining the strategy that will lead to the most success in performing the motor skill operation. The investigation also provides another potential link with implicit learning theories. The participants' discovery of the correct strategy reinforces the contention that too much inward focus can result in unsuccessful performance. If one is too aware of oneself (explicit learning) when performing the task, the outcome is not likely to be of a successful nature.

Wulf et al. (1998) examined internal/external foci in an investigation of differing instruction styles used in motor skill learning. They attempted to determine the effectiveness of instructions referring to a person's body movements (internal focus) in comparison with feedback that directed the individual's attention away from their body movements and toward the resulting effect that the movements may have on one's environment (external focus).

Wulf et al. (1998) required participants to attempt slalom-like movements on a ski-simulator. Participants were randomly assigned to one of three groups. Learners were instructed to either exert force on their outer foot (an internal focused instruction type) or

to exert force on the wheels of the ski-simulator (an external focused instruction type). A control group, which received no instructions, was also included in the experiment. After two days of practicing the ski-simulator tasks, the participants' learning was assessed. Wulf et al. (1998) reported that after the practice sessions were completed, the external-focus group showed greater increments of improvement in relation to those of the internal-focus group. Interestingly, the internal-focus group was also outperformed by the control group, which did not have the benefit of receiving any instructions. Apparently, being made aware of one's body movements can have detrimental effects upon one's performance of a motor skill task. These detrimental effects suggest that an individual's awareness should be directed away from oneself and toward the external environment in order to achieve optimal performances. Wulf et al. (1998) mentioned that instructions should be given in a manner that will distract individuals so that they are prevented from concentrating on their body movements. This should enable them to focus instead on the effects that their body movements have on the execution of the task.

Wegner, Ansfield, and Pilloff (1998) suggested that there are situations when individuals find themselves producing movement errors that represent the "ironic opposite" (p. 196) of what they intended to accomplish. They found that subjects were more likely to commit movement errors that were the opposite of their intended actions when they were monitoring their actions visually. Each participant putted a golf ball on a carpeted surface in a room lit by ultraviolet light. The ultraviolet lighting allowed for the manipulation of visual monitoring as some participants used a golf club (putter) that glowed orange under the lighting enabling them to easily monitor their or the golf club's

movements. Other participants used a black putter that was difficult to see under these conditions and thus they were not able to easily monitor the movements.

Wegner et al. (1998) also found that ironic errors were particularly likely to occur after explicit instructions to avoid such errors were given to the participants. The explicit instructions combined with the unusually high visual focus generated from the ultraviolet light atmosphere seemed to have effects on performance similar to the Wulf et al. (1998) manipulations in that overall performance was significantly compromised. Wegner et al. (1998) suggested that under excess mental load, intentions to control the mind unleash an “ironic monitoring process” (p. 196) that appears to create failures that are cognitive, emotional, and motoric. Participants attempting not to overshoot a golf putt were induced to significantly overshoot when this mental overload was present. It was also noticed that when people were forced to visually monitor their behavior, motor control is undermined to the point that the least wanted movements are the end result. Basically, when individuals who were tested in an excessive load condition attempted not to perform simple motor actions, the occurrence of unwanted actions become more likely. This result would lead one to surmise that excessive awareness is a source of interference that can prevent someone from successfully executing a motor task.

Wegner et al. (1998) carried out a second experiment subjecting participants to one of two conditions while performing the motor skill task of swinging a handheld pendulum. Participants were either subjected to an excessive mental load by having to count backwards from 1000 by three's or were subjected to an excessive physical load of having to hold a brick in the outstretched arm that was not involved in the motor task. Both groups were given explicit instructions on how to perform the task. Wegner et al.

(1998) reported an ironic process, which seemed to take control of the individuals' motor actions. These movements were characterized as the "least wanted movements" (p. 199) that a participant was attempting to accomplish. For example, when one attempted to follow the explicit instructions of the experimenters and attempted not to swing the pendulum in a particular direction, it was exactly in this unwanted direction that the participant was likely to swing the pendulum. The results of the Wegner et al. (1998) experiments are consistent with previous investigations that found ironic actions resulting from conscious attempts to ensure the proper execution of a motor skill task (Baumeister, 1984; Linder et al. 1997)

Wegner et al. (1998) mentioned that it appears that the distraction (which was caused by the institution of the secondary task) can undermine motor control to produce errors in movement. The researchers' belief is consistent with that of Hsiao and Reber (in press) in that, considering the role of attention as being the issue, the introduction of a secondary task will almost always lead to a decrease in implicit learning. Another issue of importance may be related to the experience of an individual performing the task under conditions of distraction. Could it be that the distraction (mental overload) used by Wegner et al. (1998) produced unwanted movements because they were unpracticed events? It is certainly possible that there are distinctions that need to be identified in the motor skill area to determine when an individual needs to be aware and explicitly focused on the task that is being undertaken and when he or she can be unaware and rely on automatic processes effectively.

Rejeski and Kenney (1987) found that participants who were asked to perform simple and complex cognitive tasks while performing an endurance motor skill

(maintaining an isometric contraction on a hand-grip dynamometer) displayed greater endurance abilities than those in a control group that did not perform the cognitive tasks. Participants performing dissociative cognitive tasks were placed in one of two groups. Individuals placed in the simple cognitive task group were required to count backward from 1000 aloud. In contrast to those performing the simple cognitive task, individuals placed in the complex cognitive task group attempted a sequential mental arithmetic task. Varying the complexity of the cognitive task (simple versus complex) had no significant effect on endurance time. Results revealed that participants performing either type of dissociative cognitive task displayed greater endurance than those in the control group who were not subjected to these tasks. This finding suggests that when we are not explicitly focused on a task, performance can be enhanced compared to when we are focused on a task. This finding appears to be consistent with those of Masters, Wulf, and their colleagues in that they all appear to support the contention that individuals have a tendency to fail when they have too much conscious focus and awareness during the performance of a motor skill. It also supports the argument that too much focus of one's attention may be detrimental in the performance of endurance skills. The awareness of one's fatigue can lead to unsuccessful attempts in the performance of that particular skill.

Certainly, a case can be made that the ideas of Rejeski et al. (1987) have more to do with tricks to avoid pain rather than fitting nicely into the internal/external debate of Wulf. In addition, in the purest sense, it may not fit perfectly with Masters' ideas because of the very nature of an endurance skill, which may not be considered a complex motor skill activity. Despite these cautions, Rejeski et al. (1987) does make the point that too

much attention does hinder performance and this in itself does support the overall inquiry.

Singer et al. (1993) carried out a study examining whether the learning and performing of a self-paced motor skill task could be accomplished more efficiently by participants utilizing an awareness strategy as compared with participants utilizing a nonawareness strategy in a dual-task situation. The primary task was an overhand throw at a target using the nondominant hand. The participants were required to throw paddleballs at a circular target located 3.66 meters away. They were required to bounce the ball on the metal surface floor before striking the target. The secondary task was a verbal task that had the participants listening to a sequence of numbers as they were preparing to throw the paddleball. The participants were required to call the next number in that particular sequence just before throwing the ball.

Singer et al. (1993) divided the participants into four groups. Individuals placed in an awareness strategy group were encouraged by the experimenters “to consciously attend to each act, to be aware of the task situation, and to be aware of body parts during execution” (p. 22). They were instructed to be aware of the manner in which they threw the ball at the target and to focus on specific cues such as the movement of the ball or the noise of the ball hitting the target. Individuals placed in a nonawareness strategy group were guided to perform the task without focusing on oneself or on the multitude of situational details available to them. Specifically, the nonawareness participants were instructed to preplan the movement, to focus on only one situational cue (such as the center of the target), and to ignore movement information and other contextual cues. Basically, this group was told to “just do the task” (p. 22). Individuals in a third group

used a middle-ground strategy that was based on mental preparation procedures such as imagery. This strategy is similar to the nonawareness strategy except that more considerations are included when preparing for the act. The remainder of the participants who were put in a no strategy condition only received information regarding the basics of the task and the importance of the study.

Singer et al. (1993) found that participants in each of the three strategy conditions displayed more proficient ball-throwing abilities than those in the no strategy control group. Furthermore, there was evidence suggesting that novices utilizing a nonawareness strategy would perform a self-paced repetitive motor skill task more effectively than would novices utilizing an awareness-type strategy. While, nonawareness strategies are usually reserved for expert performers, in a laboratory setting it appeared that novices were able to successfully use this type of approach. Singer et al. (1993) noted that individuals utilizing a nonawareness strategy were aided in becoming more efficient in the execution of the task because they avoided the distractions that can be caused by focusing on oneself and on situational information. They admitted that their conjecture might be viewed as controversial considering the fact that psychologists who have studied performers at all levels of competition (e.g., Csikszentmihalyi, 1990) have been unable to provide scientific evidence supporting the use of nonawareness strategies.

The interpretation of the findings of the Singer et al. (1993) investigation appears to be consistent with the implicit learning perspective as participants who were basically performing with unconscious processes outperformed those who were thinking about their own actions too much. The participants who were unaware of self and situation appeared to perform in the automatic fashion that has become a trademark of implicit

learners. When one is performing in an implicit manner, with little or no focus on oneself or one's body movements, execution of the task can be almost effortless with the individual achieving a state of mindlessness (Langer et al., 1979). Achieving this mindless state, where one's focus and awareness are not part of the scenario, appears to facilitate an expert-like execution of complex motor skills. Often individuals are able to perform the appropriate movement at the appropriate time when they are in a state of automaticity (Singer et al., 1993).

Reinvestment of Conscious Processing Theory

Masters et al. (1993) addressed the possibility that the reinvestment of controlled or conscious processing may be a dimension of personality. They suggested that some individuals have a greater predisposition than others to reinvest actions with attention. This is especially the case during pressure situations. Masters et al. (1993) hypothesized that certain individuals may have a predisposition toward the reinvestment of controlled processing, and there might be an inclination to introduce conscious control of a particular movement (such as a motor skill) by isolating and focusing on specific components of the skill. In an attempt to identify the personality types that might be most vulnerable to reinvestment, they utilized three existing personality scales related to the concept of reinvestment. The three personality scales incorporated to structure a reinvestment scale were the Cognitive Failures Questionnaire (Broadbent, Cooper, FitzGerald, & Parkes, 1982), the Rehearsal factor of the Emotional Control Questionnaire (Roger & Nesshoever, 1987) and the Public and Private factors of the Self-Consciousness Scale (Fenigstein, Scheier, & Buss, 1975). Factor analysis performed on these three

scales, relating to the concept of reinvestment, uncovered a reliable tool for measuring such a construct.

Masters et al. (1993) recommend the use of this 20-item scale of reinvestment as a way to measure a person's susceptibility to public and private self-consciousness. Additionally, they claim that the scale has a relatively robust internal and test-retest reliability and predictive validity insofar as "the correlation between the tendency towards reinvestment and the tendency towards skill failure under pressure" (p. 664) is concerned.

Masters et al. (1993) suggested several important components of reinvestment that can be traced back to one's personality type. First, they surmised that individual differences in self-awareness could be an important factor in determining whether an individual would be more likely to reinvest in a conscious processing. They argued that the greater a person's predisposition toward self-consciousness, the more likely he or she will be to think about what they are doing, and ultimately the greater the chance that reinvestment will occur. When someone is explicitly instructed to focus on his or her body during the performance of a task, it might be expected that a highly self-conscious individual will become more aroused than a less self-conscious person. Additionally, self-awareness has been shown to increase in situations resulting in increased arousal (Fenigstein & Carver, 1978; Wegner & Guiliano, 1980).

A second component of reinvestment mentioned by Masters et al. (1993) has to do with one's vulnerability to stress. They suggested that some individuals are less able to resist the effects of stress because of their personality type and for this reason they may have a greater predisposition to cognitive failure especially when involved in a pressure

situation. For instance, Broadbent et al. (1982) found that student nurses failing their final-year examinations had high scores on the Cognitive Failures Questionnaire. They also showed conclusively that the general health of nurses working in highly stressed conditions correlated highly with their scores on the Cognitive Failures Questionnaire. It seems that some people are more susceptible than others to the adverse effects generated by stressful conditions.

Masters et al. (1993) mentioned that a third component of reinvestment may be rehearsal and defined this factor as one's tendency to mentally rehearse emotional events. They surmised that one might rehearse rules associated with a skill just as one would rehearse an emotional event. They suggested that people with a predisposition towards rehearsal might be prone to anxiety when faced with a stressful situation.

Masters et al. (1993) utilized a two-dimensional rod-tracing task to test participants. The two-dimensional rod-tracing apparatus that was employed "consisted of a length of copper rod 1 cm in diameter and 180 cm in length, bent into a rough vertical 'M' shape 55 cm in height by 50 cm in width and mounted on a secure base. A hand-held ring stylus 2.5 cm in diameter encircled the copper rod" (p. 659). Participants attempted to move the stylus from one end of the rod to the other without making contact with the copper tubing. They were instructed to make as few errors as possible and it was made clear that no time restraints were being imposed. Stress was introduced by informing participants that each error would result in a reduction in the amount owed them for participating in the experiment. Somewhat unexpectedly, Masters et al. (1993) reported that high reinvestors were not more likely to fail under pressure than low reinvestors.

Masters et al. (1993) considered the possibility that the motor skill utilized was not complex enough and did not create the kinds of demands that would call for greater rule use. The skill employed was most likely too simple and/or devoid of rules to result in reinvestment of conscious processing under pressure. Since the rod-tracing task involved very few technical components about which rules could be explicitly formed, there was very little need for controlled processing or the likelihood of a breakdown of automatic processes. This conjecture was supported in a follow-up study that contrasted the scores of participants from an earlier study who had performed a golf-putting task (Masters, 1992). Masters et al. (1993) found in their second experiment that there was a correlation between reinvestment scores and failure of skill in the putting task. Here, the task had many rules and technical components that could be explicitly formed. Controlled processing was more evident and deautomatization was more likely. During the execution of these complex skills, controlled processing has a greater likelihood for disruption. Therefore, it is quite reasonable to believe that one's cognitive processes become more of an influential part of the entire picture as the task becomes more complex.

Masters et al. (1993) concluded that the results of the second experiment indicate that reinvestment is a valid concept because the scale accurately predicted those individuals who showed a decrease in their performances on the complex task. They suggested that the drop in performance occurred because of a tendency toward a reinvestment of controlled processing. Individuals considered high reinvestors were more likely to fail or deautomatize under pressure. Although, more research is required concerning the predictive power of the reinvestment scale, it appears to have some

potential as a means for identifying people who may be unsuccessful in stressful conditions.

The Yerkes-Dodson law may be operating in Masters et al. (1993). It appears that the increased levels of arousal induced by financial incentives may actually serve to benefit a person in the execution of a simple task such as rod tracing. If the increase in arousal is not too high, one can expect to see enhanced performances on simple tasks. In contrast to this, on the complex task that involved putting a golf ball, increased arousal levels appear to create some interference that prevents one from achieving optimal performance in the execution of the task.

Baumeister (1984) carried out a series of experiments that examined the role of conscious attention in a motor skill task. In one experiment, participants attempted to score points by moving rods horizontally across a board so that a metal ball resting on the rods will drop into holes on a platform located beneath the rods. The participants were either told to focus their attention on the movements of their hands as they executed the task or told to focus their attention on the ball. The increased conscious attention to one's body and body movements led to poorer performances in the motor skill task.

Participants who focused on the outcome ("ball condition") performed significantly better than those focusing on oneself ("hands condition"). Baumeister mentioned that when an individual is consciously monitoring their muscle movements, performance is likely to suffer. Thus, conscious attempts to make certain a task is performed in the correct manner can ironically lead to detriments in performance (Wegner et al., 1998). The interpretation of Baumeister's finding is consistent with the findings of Wulf and her colleagues in their

experiments on internal vs. external foci of attention (Wulf et al., 1998; Wulf et al., 1999; Wulf et al., in press) and with Wegner et al. (1998).

Baumeister (1984) also examined the effect that a stressful situation can have on a performer when he or she is attempting to execute a motor skill task. This experiment added a stress factor to the same task that was used in the earlier experiment. A cash incentive was offered to any individual able to attain a high level of accomplishment, which was determined on an individual basis from scores attained during practice trials. This procedure was carried out so that a level could be computed that was reasonably attainable but would require a participant to perform well for his or her ability level. Additionally, the Self-Consciousness Scale (Fenigstein et al., 1975) was utilized so that self-consciousness levels could be determined for each participant. Baumeister hypothesized that participants who scored low on the Self-Consciousness Scale would perform not perform as well in the cash incentive condition than they had in the earlier experiment in which no money was involved. Interestingly, all participants regardless of their level of self-consciousness (high or low) performed less efficiently in the incentive condition than they had earlier in the non-incentive condition. Baumeister noted that “offering a reward for improved performance paradoxically caused subjects to perform worse” (p. 617).

Baumeister’s (1984) studies may have several important implications regarding the implicit learning/sensorimotor connection. It may be possible that the added influence of a cash award can make an individual revert to an internal focus, regardless of their self-reported degree of self-consciousness. It appears that when there is an added importance attached to one’s performance, an increased internalized focus can cause performance to

suffer. In situations when the individual is under pressure to perform at an exceptional level, precisely the opposite can occur because of the added awareness and focus the individual may have. In these stressful scenarios, it seems that the individual is operating on explicit and reflective cognition rather than on the implicit and nonreflective cognition that apparently was the case before the environment became stressful. Baumeister suggested that the demands on someone to achieve excellent performances could actually lead them to attend consciously to internal processes with a result of having conscious attentiveness disrupt the entire process. Baumeister's viewpoint is consistent with the views of Masters et al. (1993) concerning the reinvestment of conscious processing. The individual seems to be experiencing an increased conscious attention to oneself and this apparently is a disruption to any automatic processing that may have initially been a benefit to that person's performance.

Baumeister (1984) also suggested that the increased attention that results from a stressful situation might decrease someone's attention to the task thereby causing a drop in performance. As in the Hardy et al. (1996) investigation, it should be pointed out that financial incentives may do more than just increase arousal levels. For some, the cash rewards may serve to increase motivation and competitive desires to perform better. Baumeister's experiments support earlier research that provided evidence that increased levels of arousal lead to an increased attention to self (Wegner & Giuliano, 1980). When people realize this increased attention, they may become so overwhelmed with internalized thinking that a successful execution of the external task becomes less likely.

From a review of the literature, it seems plausible that Reber's views concerning implicit processes might also have a place in the sensorimotor domain. The precise extent

of the role that implicit processes play in sensorimotor operations is conjecture at this point. Although, the amount of research in this area has increased recently, empirical findings on the subject are still in their formative stages.

Practical Implications—Sports Psychology

Boyce (1987) mentioned that one of the most valuable resources that an athletic coach or teacher can offer an athlete was feedback concerning the correctness of a particular movement. However, this statement may be paradoxical since potential obstacles often prevent this feedback from being communicated so that the player attains an increased level of performance. Salmoni, Schmidt, and Walter (1984) stated that although feedback could be beneficial in guiding an individual to correct movements, it could also lead to a dependence on feedback, which could cause detriments in learning. This could especially be true during the actual event when the coach or instructor is temporarily unable to convey his or her wisdom to the performer because of sources of interference inherent in the event. Such interference might include crowd noise, game situations, and pressures that are not usually present when feedback is normally transferred from coach to player.

To take a real world example, it may have been a similar scenario that led to Shaquille O'Neal's inability to benefit from explicit instructions given in a controlled environment — a practice session. In 1994, O'Neal a seven-foot-one, 303 pound, National Basketball Association superstar with a \$40 million contract, was, statistically, one of the worst free-throw shooters in the history of the game (Men's Journal, 1994). He was so bad, in fact, that opposition players would often foul him intentionally because

they knew that his chances of scoring from the foul line were dramatically less than from the floor. While playing for the Orlando Magic, management brought in Buzz Braman, one of the most respected shooting coaches in the country, to work specifically and solely with Shaq. All feedback was of an explicit nature involving body and arm position and focused specifically on the forming of a precise angle between the forearm and the upper arm. It initially appeared to help, as O'Neal's shooting in practice increased dramatically. Unfortunately, during game situations O'Neal did not improve. If anything, he got worse. Eventually Braman was fired and O'Neal was traded.

At first glance, we again seem to have this paradoxical situation concerning feedback. One would think it should be a major benefit to the athlete, yet an instructor's feedback can often lead to quite contrary results. A possible reason for this has to do with the nature of the instruction. If the athlete is given too much feedback that is basically internal in its focus, he or she may not be able to process this type of feedback automatically when sources of interference are present during the actual event. Braman, a technique tutor, probably saw his project fail because his teachings were basically explicit in nature. He felt that shooting slumps were 90% mechanical and stressed such things as maintaining a right angle formed by your upper arm and lower arm as you shoot.

Singer et al. (1993) reported that when beginners are instructed, traditionally "they are told to pay attention to what they are doing and to think about the act during execution" (p. 19). Coaches alert players to be aware of movement cues and their body parts while performing the act. Unfortunately, this awareness strategy may not allow one to reach peak performance levels during competition. They speculated that novices might

be able to effectively adopt strategies that heretofore have been limited to well-practiced, expert athletes. They provided evidence that suggested that beginners especially for relatively brief, self-paced repetitive acts could use a nonawareness strategy effectively.

Unfortunately, it appears that individuals who appear to come from an “old school” of thinking are coaching most of today’s youth. These coaches use traditional methods of instruction. It may be possible that instructions that refer to the coordination of the performer’s body movements will not lead to optimal performances (especially in stressful or pressure situations). This “old school” type of coaching still appears to be the most common form used by coaches at all levels — novice to expert, and especially for beginners. Wulf et al. (1999) strongly suggested that novice golfers should not be instructed in this manner.

One distinguishing quality, which seems to support the need for automatic processing during athletic events, has to do with the large amount of interference that is usually present during these events. As was previously mentioned, many of these sources of interference are related to pressures that an athlete is subjected to during the event. In addition to the stress from pressures relating to and resulting from crowd noise, game situations, and opponents, athletes are subjected to fatigue factors. Very often players are required to perform at their best during critical elements of an event when fatigue may be at its highest level.

Rejeski et al. (1987) mentioned that interference associated with fatigue might be particularly evident in endurance events. Athletes such as long-distance runners, bikers, and swimmers may be at less risk for fatigue if their attention is elsewhere. They suggested that individuals could improve endurance performances by using a dissociative

strategy or coping technique that could shift their focus away from the task. Similar to skill athletes, most endurance athletes appear to perform at a higher level when attention is diverted somehow.

An important question and possibly the crux of the entire dilemma posited here has to do with what type of coaching strategy can be used most effectively in contemporary sporting events. Can basic psychological principles, such as those embedded in the work of Reber and his colleagues on implicit learning and that of Masters and of Wulf and their colleagues on sensorimotor skills, tell us about how applied problems in coaching and sports psychology should be managed? Should today's instructors continue to use traditionally explicit learning strategies? Or should coaches abandon these techniques in favor of implicit learning approaches?

Annett (1991) hypothesized that different processes may actually lead to better performances at different stages of learning. He argued that one would need to consider the possibility that a combination of implicit and explicit coaching strategies may be required to produce the best outcomes. Hardy et al. (1996) expanded on this theory by adding that explicit and implicit learning strategies are likely to vary as a function of task demands. Could there be sport-specific differences concerning how much of an athlete's cognitive element is interacting with their motor element? For instance, it appears that for various team and individualized sports, athletes involved may call upon an increased mental component to help them execute properly. A pitcher in baseball or softball, for example, may not have his or her good fast ball on a given day or night yet still manage to be successful by changing the speed and location of the pitches thrown. This strategy often has the positive effect (for the pitcher) of keeping opposing hitters off-balance. In

other sports, the mental component may not be as important for sports psychologists to be concerned about.

Currently, it appears that researchers are struggling with the implicit/explicit and internal/external focus questions insofar as athletic implications are concerned. For example, Janelle, Kim, and Singer (1995) believe that one of the most valuable resources a coach can offer an athlete is feedback regarding the correctness of specific movements whereas Salmoni et al. (1984) oppose this view, believing that it is desirable to lead subjects away from feedback reliance. Salmoni et al. (1984) claim that we should focus attention on the task and sensory qualities involved. Again, the coaching implications are presented with an additional twist. Apparently, instructors must not only be concerned with the task involved (sport-specific) but with the type of individual they are dealing with.

Masters (1992) provided evidence that was critical to the explicit methods of coaching that have heretofore been accepted as the correct way to lead athletes to successful performances. He argued against the use of prolonged explicit instruction and mentioned that the use of such could have detrimental effects on athletes of all levels. It was Masters' contention that even an elite athlete trained under explicit coaching styles would be likely to fail under the pressures involved in the live event. Could it be that athletes trained by explicit coaching methods are more likely to be affected by the pressures inherent in their sport? There appears to be an growing amount of evidence suggesting that explicit methods can contribute to breakdowns in one's automatic processes and thereby increasing the chance of "choking" on the part of the athlete (Masters, 1992). There also appears to be some evidence that traditional instructions

referring specifically to an athlete's body movements can be disadvantageous (Wulf et al., 1998; Wulf et al., 1999; Wulf, 1999; Wulf et al., in press).

Why are some athletes more successful than others in learning and mastering skills, as well as achieving in competition? What causes a marginal athlete to excel during the final minutes of a game when many elite athletes are not able to cope and ultimately fail under the pressures of these situations? From carrying out an extensive review here, it appears that some individuals who are successful during these instances may be using an external focus and thus are operating on the automatic processes involved in implicit learning systems. If an athlete has to consciously reach back to evaluate the situation, to think about the needed mechanics involved in the execution, or is too aware of oneself when attempting the skill, there may be a greater chance that the ensuing performance will be less than what would be expected when the skill level of the athlete is taken into consideration.

The preceding review suggests that there have been increased research efforts investigating the implicit learning/sensorimotor learning connection over the past decade or so. Still, psychologists have only scratched the surface of this area of study. It seems reasonable to suggest that researchers are currently being confronted with a psychological dilemma with important practical implications that need to be investigated further. The purpose of this study is to extend Wulf's investigations concerning the differential effects of internal vs. external focus of attention while blending her ideas with those of Masters' from the sensorimotor domain and with those of Reber's from the cognitive domain.

In general, Wulf's research focuses on how the learning of motor skills (e.g., sport skills) can be enhanced so that skills are acquired faster, are retained better, and transfer

to new skills is facilitated. In particular, she is interested in how learning is affected by the learner's focus of attention, the frequency and type of feedback, as well as the relative effectiveness of implicit vs. explicit learning.

The current investigation will attempt to utilize a complex motor skill (a "free throw" basketball shooting task) that might be considered somewhat paradoxical in nature. Interestingly, it is not uncommon for some of the best performers in the sport of basketball to struggle at this task while players with lesser abilities sometimes excel. Its use is expected to be appropriate to this investigation because of the complicated elements involved and the subsequent demands that would call for greater rule use by participants. Besides this distinctive motor skill task another novel ingredient to the design has to do with forcing some of the participants to use an unpreferred focusing strategy. This is expected to further accentuate Wulf's views favoring an external focus and Masters' and Reber's views favoring implicit learning.

A novel manipulation included in this design might be referred to as the "forced-opposite." During the testing phase, half of the participants were instructed to shoot in a manner opposite of their previously declared preferred focus. In essence, there were two primary factors: (a) internal vs. external focus and (b) preferred vs. non-preferred shooting style. For this study, it was hypothesized that an external focus would promote implicit processes to the point where there would be significant differences in the performances of the four experimental groups. Specifically, participants forced to shift from a preferred external focus to a non-preferred internal focus should show the lowest performance. Such an outcome would not only add credence to Wulf's and Masters' theories but might also have an impact on what is most effective for training athletes.

There are many issues involved that may be beneficial to sport psychologists in helping athletes to reach and maintain optimal performance levels.

METHOD

Participants

The data for this investigation were obtained from 100 individuals, eight of whom were participating as part of their requirement in an introductory psychology course at Brooklyn College and 92 of whom were volunteers obtained from a health/fitness club located in Stamford, CT. Both males (66) and females (34) were tested in this investigation.

Materials

Participants were required to complete Masters et al. (1993) 20-item scale of reinvestment (See Appendix A), which, as noted above, appears to illustrate a person's susceptibility to public and private self-consciousness. Spaces were provided on this questionnaire for the purposes of recording participants' age and sex. The only other material that was utilized in this study was a Rawlings official NCAA basketball that each participant used during the shooting task.

Procedure

The experiment was conducted on an indoor basketball court located on the Brooklyn College campus and a similar environment located at a community center in Stamford, CT. The participants' were instructed to shoot an official NCAA basketball from the "free throw" line located 15 feet (regulation distance) from the basket. The basketball-shooting task was chosen because it is a complex task involving the use of

several different body movements including one's arms, hands, legs and feet. An explanation to participants outlined the purpose of the study. Specifically, they were told that we were attempting to uncover the efficacy of different focusing strategies employed in a complex motor skill activity.

The experiment consisted of three phases:

Phase 1

During this initial phase of the experiment, each participant performed 50 trials under no instruction. This was done to determine baseline skill levels for each participant. After a short one-minute rest period Phase 2 commenced.

Phase 2

During the second phase of the experiment, participants were instructed on the use of two focusing strategies that they could try as they attempted the basketball-shooting task. The internal focusing strategy was described first. This instruction took place at the free-throw line. After the participant acknowledged that he or she had fully understood the instructions, they proceeded with ten free throws using this strategy. Next, the external strategy was described to the participants. Again, after acknowledging full understanding of this strategy, the participants continued by attempting ten free throws using this strategy. After a one-minute rest period, participants were then asked to reverse strategies and attempted an additional 15 shots using the internal method. Once these shots were taken, participants were again given a one minute rest break and then asked to switch strategies and attempted 15 more shots this time using the external method.

The trials in Phases 1 and 2 were summed and then averaged to give participants a pretest score. This resulted in 100 shots included in the pretest. To give participants their

pretest score, the number of successful shots was divided by two. This allowed for a fair comparison with the posttest (50 shots).

Phase 3

There was a third phase to the experiment. However, since this phase involves shifting strategies, it will help to describe the Internal and External Focus Strategies first.

Internal Focus. Participants when using the internal strategy were asked to concentrate on their arm angles (forearm and wrist) relative to the upper arm and of the positions of their legs and feet while shooting the ball. Participants were instructed to concentrate on specific body movements. To best illustrate this strategy, gesturing to specific body areas was deemed necessary. For example, statements such as the following were used: “as you are preparing to shoot the basketball try to think about your arm and wrist angles. Notice that when I bend my elbow to shoot I am forming a right angle or ‘L’? Think about this as you are shooting the ball. Also, think about your feet position and if you bend your knees think about this, too. Think about all your body movements and angles.”

External Focus. Participants using the external-focus were asked to concentrate on anything that was not considered to be associated with the person’s body but, rather, to focus on the basket itself or some other aspect of the immediate environment. Participants were reminded that it did not matter what specific thing that they focused on or thought about as long as it was away from the internal focus (the body). During the description of this strategy, again the usage of a visual teaching method was employed to put emphasis on the verbalizations associated with the task. In this instance, external situational cues such as the ball, the basket, and the floor were used as examples that the participant could

choose from as his or her focus when performing the task. The following statements were typically utilized: “as you are preparing to take your shots, try to think of all things situated away from your body that might help you to make the shot. For example, think about the ball or the basket, maybe the net or the back of the rim. Glancing at the floor to help you judge the distance you are from the basket might also help. This time do not think about your body, instead put all focus on things away from your body.”

During the testing phase, each participant was reminded of the two attentional strategies and requested to state which one that they preferred. Once this information was obtained, half of the participants were instructed to use their preferred strategy and half were instructed to use their non-preferred strategy. After agreeing to use the authorized strategy (either “preferred” or “forced opposite”), participants were required to perform an additional 50 trials. There were no time restrictions placed on the participants. Participants were also informed that a \$5 prize would be given to anyone improving their shooting accuracy 15% or more from Phase 2.

In order to ensure that an approximately equal number of subjects were placed in the “preferred” and “forced opposite” testing conditions, a random sampling without replacement was utilized. There were, however, unequal numbers in the four testing groups because there was no way to control for the differences in participants’ preferred focus. This procedure produced four testing conditions: (1) “external-focused preferred” group using external-focus strategy (EE), (2) “external-focused preferred” group using internal-focus strategy (EI), (3) “internal-focused preferred” group using external-focus strategy (IE), and (4) “internal-focused preferred” group using internal-focus strategy (II). Once the 50 test free throws were completed, each participant completed the

Reinvestment Scale (Masters et al., 1993). Participants were assured that confidentiality would be maintained concerning his or her answers on this scale. The total duration of the experiment, including the debriefing of participants, was approximately one hour. A schematic outline of the time course of the full experiment is given in Figure 1.

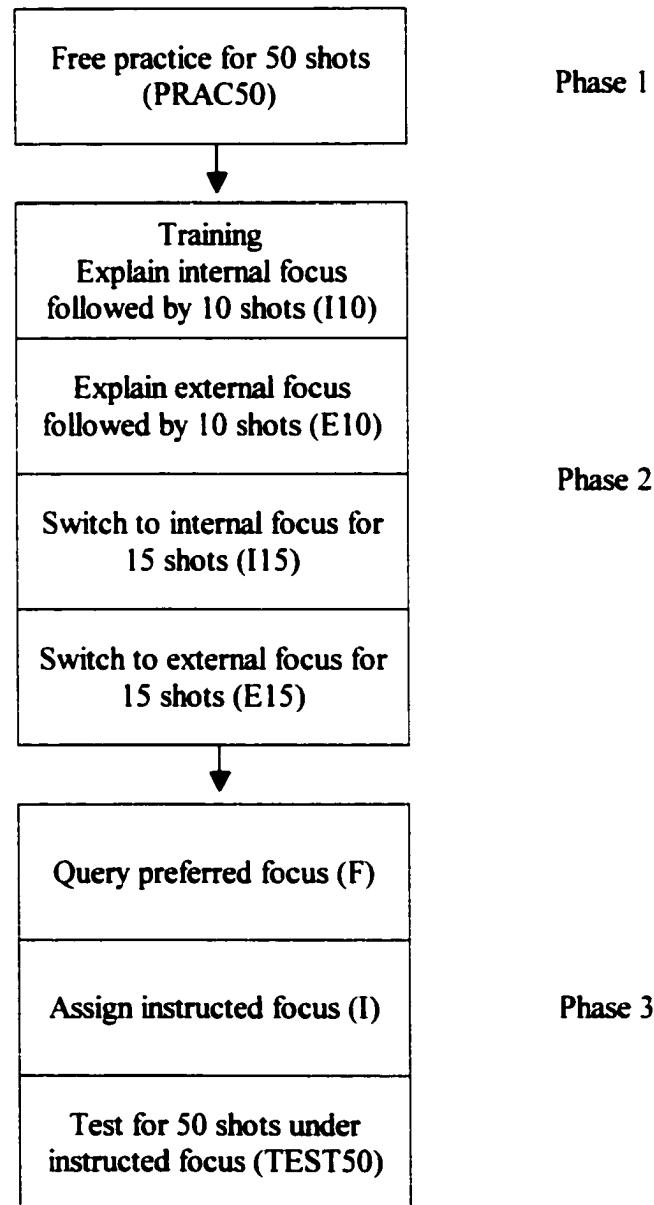


Figure 1. Flowchart of time course of full experiment.

HYPOTHESES

Considering the theoretical arguments presented above, it was expected that certain potential vulnerabilities are inherent to an internal focusing strategy and that an external focusing strategy is advantageous when attempting to execute the complex motor skill involved in this experiment. When participants are put in stressful environments (such as Phase 3), these effects are even more likely to manifest. The novel aspect of the current investigation of allowing some participants to shoot a basketball using their preferred focusing strategy and forcing others to shoot using their unpreferred style should lead to dramatic differences in performance depending on the different foci. Therefore, it is hypothesized that there will be group differences in free throw shooting accuracy under pressure. Specifically, those using the external focus for their posttest (EE and IE groups) would be expected to show significant improvement in a prepost test. It is also expected that the groups using an internal focus on the posttest (EI and II groups) would show less improvement. The EI group is expected to be especially vulnerable to the effects of the manipulation. This is the only group forced to switch from a proposed better strategy to a less effective one. Therefore, it is hypothesized that EI will not perform as well as the others on a prepost test. The rationale for this prediction comes from previous research by Masters on implicit vs. explicit learning and by Wulf on internal vs. external foci of attention. These studies have identified some of the reasons why a person fails when trying to execute a complex motor skill. An inward focus of attention and an explicit, conscious type of processing appear to be poor strategies when carrying out a complex motor task. As noted above, this is the only experimental condition that forces its

participants to downgrade from a superior strategy to an inferior one. The likely vulnerabilities of using an internal focus have been outlined above. A disruption of automatic processes is likely because of the inherent nature of the external focus. For these reasons, it is expected that differences will be found in the four experimental groups concerning their prepost test scores.

RESULTS AND DISCUSSION

Analysis of Experimental Groups' Performance

A 2 (preferred focus: internal vs. external) $\times$ 2 (instructed focus: internal vs. external) $\times$ 2 (prepost: phase 1 and 2 [combined and averaged scores] vs. phase 3) analysis of variance (ANOVA) with repeated measures on the prepost factor was calculated using the ANOVA program from the Statistical Package for Social Sciences, version 10.0.7 (2000). This initial analysis investigated whether a shift in participants' prepost (P) scores had taken place and whether this potential shift was being influenced by the type of instruction (I) that one was "forced" to use. How influential the instructed focus was on prepost scores may also depend on the participants' preferred focus (F). Table 1 includes the descriptive statistics of shots made by preferred and instructed focus groups. Table 2 shows the results of the ANOVA on Pretest to Posttest differences by Preferred and Instructed Focus.

The ANOVA found several significant results, displayed in Table 2. First, the summary table did detect a trend for the three-way interaction, $p = .072$. We can see that the $P \times I$ interaction is changing depending on the levels of F. It makes the most sense to look at the $P \times I$ interaction in this manner because the type of instruction (focusing strategy) used during Phase 3 is at the crux of the argument presented here (an external focus having been predicted as being superior). The most important question (hypothesis) concerning this study is embedded in this $P \times I \times F$ trend. Specifically, instructed focus is considered to be the most important variable in determining any prepost change.

Table 1

Shots Made by Preferred and Instructed Focus Groups

Preference	Instruction	n	Statistic	Variable	
				Pretest ^a	Posttest ^b
Internal	Internal	24	Mean	20.46	24.42
			SD	9.57	9.33
	External	22	Mean	19.16	22.55
			SD	9.06	10.21
External	Internal	27	Mean	23.22	24.19
			SD	10.79	11.40
	External	27	Mean	20.81	26.22
			SD	9.21	11.12

^aPretest = (Phase 1 scores + Phase 2 scores)/2^bPosttest = Phase 3 scores.

Table 2

ANOVA on Pretest to Posttest differences by Preferred and Instructed Focus

Source	SS	df	MS	<i>F</i>	<i>p</i>
Between					
Preferred Focus (F)	191.869	1	191.869	1.005	.319
Instructed Focus (I)	27.643	1	27.643	.145	.704
F × I	34.928	1	34.928	.183	.670
Error	18330.662	96	190.944		
Within					
Prepost (P)	583.463	1	583.463	35.810	.000
P × F	2.945	1	2.945	0.181	.672
P × I	28.302	1	28.302	1.737	.191
P × I × F	53.797	1	53.797	3.302	.072
P × I at F internal	1.878	1	1.878	0.115	.735
P at F internal	309.595	1	309.595	19.001	.000
P × I at F external	87.120	1	87.120	5.347	.023
P at F external and I external	335.005	1	335.005	20.561	.000
P at F external and I internal	26.042	1	26.042	1.598	.209
Error	1564.166	96	16.293		

With this being the case, it is necessary to examine the $P \times I$ interaction at each level of F separately. First, selecting the data on participants stating a preference for an internal focus only, we can see from the summary table that there was no simple $P \times I$ interaction for those that prefer an internal focus. That is, no difference was detected in the prepost shift for instructed foci when participants' preferred focus was internal ($P \times I$ at F internal; $p = .735$). Therefore, we are witnessing essentially the same prepost change for the II and IE groups. The next part of this analysis investigates whether a prepost shift is taking place for these participants who preferred an internal focus. We can see from the summary table that there was a prepost change for participants preferring an internal focus that was significant $p < .0005$. The II and IE groups together are showing a prepost shift. As was previously mentioned, this prepost shift is not dependent on instructed focus. Specifically, the prepost change for participants preferring an internal focus illustrates an increase in performance as they made more shots during the posttest, shown in Figure 2.

The next part of this analysis that needs to be addressed concerns whether an instructed focus has an influence on prepost scores when participants' preferred focus is external. Selecting the data on participants stating a preference for an external focus only, shows that $P \times I$ at F external was significant, $p = .023$ (see Table 2). The size of the prepost change for participants using an internal instructed focus and the prepost change for participants using an external instructed focus is not the same when the preferred focus is external. Specifically, we are seeing different prepost shifts for the EE and EI groups, respectively. The amount of prepost change differs from one instruction to the other.

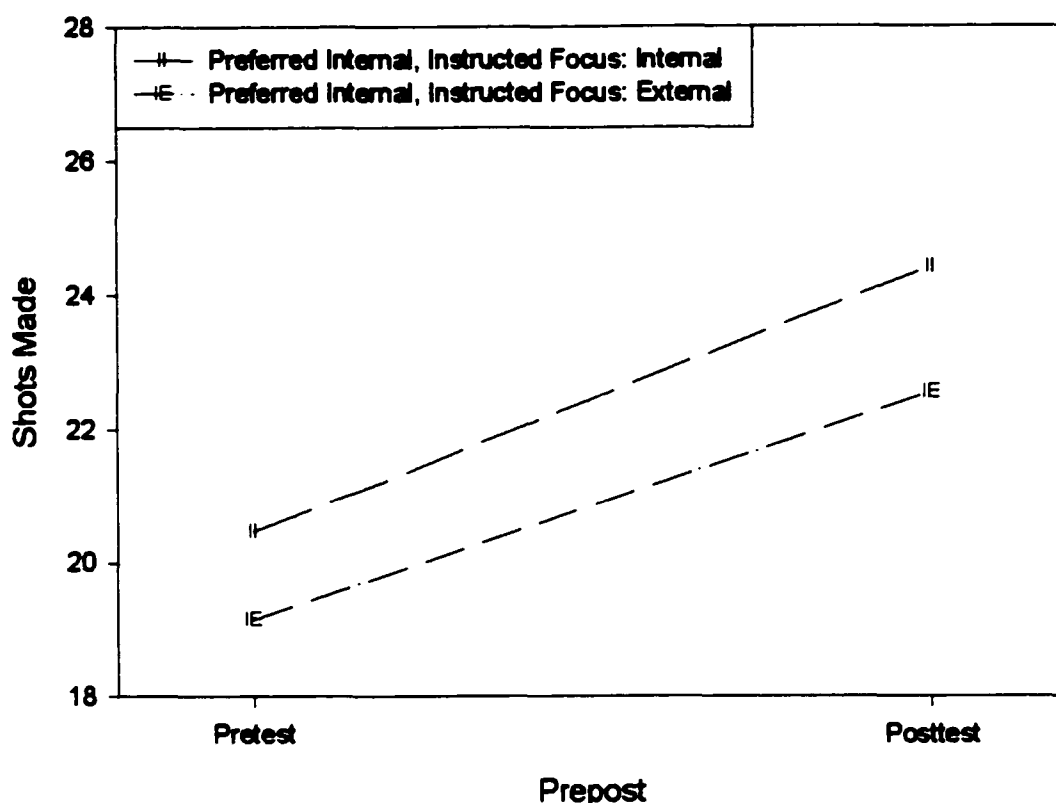


Figure 2. Simple Prepost $\times$ Instructed Focus interaction for Preferred Focus internal: IE vs. II.

From this point in the analysis, it is important to find out what takes place on the prepost test when preferred focus is external and the instructed focus is external. From the summary table, it can be seen that there is a significant change in prepost performance scores when participants are put in this condition. P at F external and I external was significant, $p < .0005$. Here, the EE group is showing a change on the prepost test.

For the last part of this initial analysis, it is also important to look at what takes place on the prepost test when the preferred focus is external and the instructed focus is

internal. This effect was not significant (P at F external and I internal, $p = .209$). Here, the EI group is not showing a shift in their prepost scores.

In finishing this initial analysis, it should be noted that participants that were allowed to shoot using a preferred focus (EE) showed significant gains in their prepost test scores while those in the “forced-opposite” condition (EI) did not demonstrate any change in their performance. This can be seen from the plot in Figure 3.

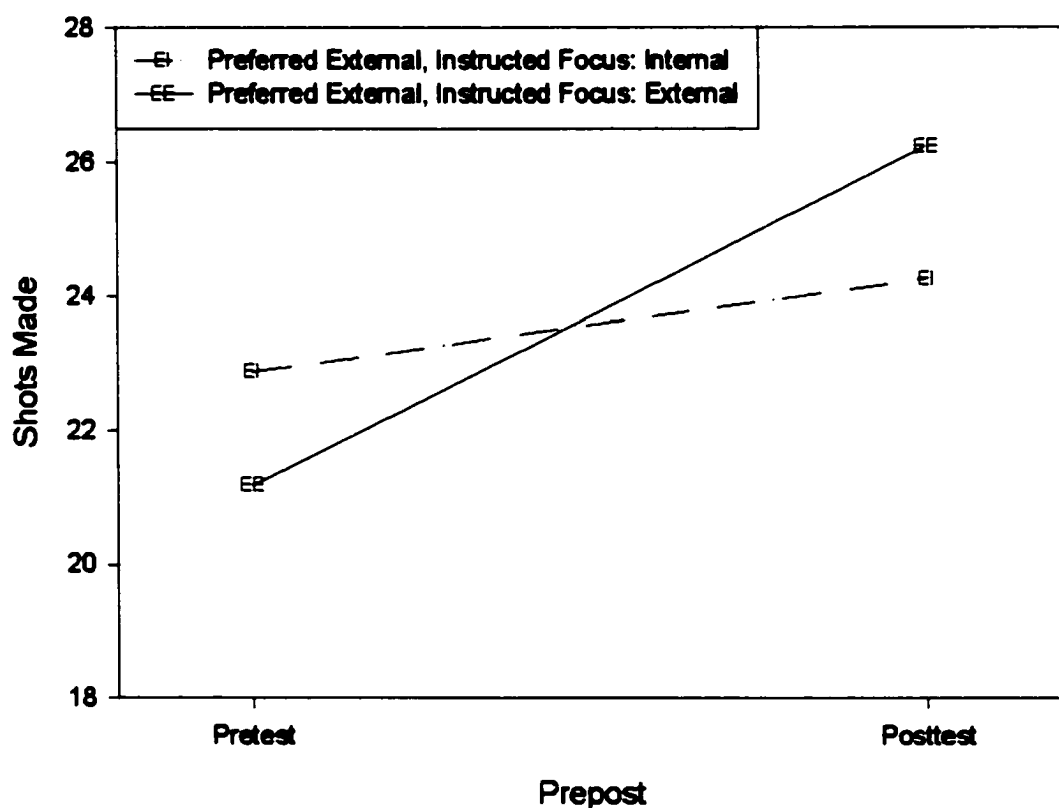


Figure 3. Simple Prepost $\times$ Instructed Focus interaction for Preferred Focus external: EI vs. EE.

The data from these analyses indicate that the EI group was the only group that did not show significant improvement during Phase 3. This is clearly illustrated in Figures 2 and 3. This finding was expected and thus confirms the hypothesis. Furthermore, the results of this experiment strongly support past research advocating the use of an external focus as a superior strategy (Wulf et al., 1998; Wulf et al., 1999; Wulf et al., in press) and thus promoting implicit learning systems. The implicit learning paradigm was first found to enhance learning on cognitive tasks (Reber, 1967) and later applied to the sensorimotor domain (Masters, 1992). When performing complex motor skill tasks, such as the one used in this experiment, an external focus appears to be the most beneficial. Concentrating on effects which are away from one's body seem to promote automaticity and thus facilitate optimal performances. An internal focus somehow appears to prevent this from happening. Wulf et al. (1998) suggested that instructions relating to a person's body movements might degrade performance. Apparently, our focus should be on the effects of our body's movements and not on our body. Again, this may also be related to the implicit learning phenomenon. When focus is on our body, the attempted learning is of a conscious type. This conscious learning does not seem to facilitate optimal performance.

When using an internal focusing strategy, there may be too much attentiveness and this can lead to a breakdown in automatic processes. In particular, when the skill is of a complex nature, this breakdown appears to manifest itself by retarding a participant's performance. In the current experiment, apparently this is what may be occurring when the EI group seems very uncomfortable with being forced to change strategies. A paradoxical effect seems to be present in this experiment. Participants in the EI group try

to perform all the correct mechanics involved in the shooting task by consciously attending to them. Despite this, the ramifications are exposing a potentially flawed focusing strategy.

Several questions exist in regards to why the EI group's difficulties persist. It may be primarily a cognitive process (conscious processing) that is causing their poor performance on this complicated motor skill task. There may also be an emotional element interacting here as well. Maybe the individual's reluctance to change strategies is causing some type of anxiety? Another possibility could be that the "forced opposite" internal strategy might not be as effective to use in a motor skill task when under pressure. If an external focus is the recommended focus, and being forced to shift strategy is detrimental, then of the four experimental groups, only EI is tested in a condition that maximally depresses performance.

It can be argued that this group was naturally operating on automatic processes. The awareness of the body movements that were necessary in the successful completion of the task was apparently done unconsciously in the external condition. During Phases 1 and 2 any learning was apparently unintentional, which is consistent with Reber's implicit learning models. If a cognitive component is involved in this motor skill task, then an argument can be put forward that automaticity is advantageous and conscious awareness of these motions might be disadvantageous. The possibility exists that the EI group was already using an advanced or "expert" technique and improvement was stifled when they were forced to try an inferior method. If this is the case, the current experiment supports Wulf's theory that an internal focus causes a disruption of automatic processes. It seems that individuals in the EI group may have become accustomed to a strategy that

was leading to success and when they were forced to abandon it, there were adverse repercussions. They probably did not have much confidence in the new internal focusing strategy and the “forced opposite” strategy seemingly caused a termination of the automatic processes present during the earlier (external strategy) trials. If this contention is accurate, it supports the idea that individuals are more likely to fail under pressure if they are too aware of what they are doing (Baumeister, 1984; Masters, 1992).

Wulf et al. (in press) mentioned that it is somewhat unlikely that performers would discover the advantages of an external focus of attention by themselves. But the possibility exists that members of this group have done just that. Participants in this group may have accomplished this feat implicitly during the brief training sessions of this investigation.

Shooting Using an Internal Focus vs. an External Focus During Phases 1 and 2

Research has indicated that different focusing strategies may have varying degrees of effectiveness during the performance of complex motor skill tasks (Wulf, et al., 1998; Wulf et al., 1999; Wulf, 1999; Wulf et al., in press). In view of this possibility, analyses of external vs. internal focusing strategies during the first two phases of this experiment may perhaps detect these differences.

Phase 1—External vs. Internal

The first of these two analyses investigated whether any discrepancy in a focusing strategy’s effectiveness might have manifested itself during Phase 1. In this breakdown, we are delving into participants’ performances before their posttest scores had been generated. There is importance to an analysis of this nature because at this point in the

design of the experiment, subjects have not been tainted by instruction. If we can assume that both the external and internal groups in this experiment used their preferred focus during the initial practice phase, then the outcome of their performances during Phase 1 might support the use of one strategy over the other.

Previously stated, the use of an inferior strategy has been linked to the failures of the EI group. The work of Wulf appears to demonstrate that, all things considered, an external focus will usually produce better performance than an internal focus. Therefore, it was hypothesized that those preferring an external focus would outperform those preferring an internal focus. To accomplish this analysis, the II and IE groups were combined to form an “internal-preferred” group and the EE and EI groups were combined to form an “external-preferred” group.

Looking at the scores during the initial practice phase (the first 50 shots taken under no instruction), Table 3 shows that there is a slight difference in the sample means favoring the combined external groups.

Table 3

Descriptive Statistics of External Preferred Focus Groups vs. Internal Preferred Focus Groups During Phase 1 (50 Shots)

Preferred Focus	<i>n</i>	Statistic	
		Mean	SD
External	54	20.91	10.84
Internal	46	18.52	9.61

As noted above, past studies recommend the use of an external focus when attempting to reach optimal performance levels. Accordingly, it was expected that participants using an external focus would produce more shots that are successful. For this reason, a one-tailed *t*-test was considered appropriate. In actual fact, no significant differences were found in the number of shots made by each group, $t(98) = 1.16$, one-tailed $p = .126$.

Certainly, an argument can be made against the assumption that every individual in these groups used the same strategy in this earlier phase that they later selected as their preference. Certainly, there is no evidence that the preferred strategy was the one that they had brought into the testing environment. This might be the reason that a significant difference was not found. Nevertheless, any hint of one strategy being superior does tend to favor the external focus (see Table 3).

Phase 2—External vs. Internal

Phase 2 consisted of each participant alternating between internal and external foci. Each participant was trained to use both focusing strategies and then preceded to alternate between the two. Each participant took 25 shots using each focus. This breakdown again attempts to detect differences in the value of the two focusing strategies before any contamination that might have resulted from the manipulation occurring in Phase 3 and before posttest scores had been generated. At this point in time, participants are only practicing different types of foci independently of the forced condition subjected on them later. In addition, there is the assumption that participants are actually doing what we are instructing them to do.

As in Phase 1, Table 4 reveals that there is only a slight difference in the sample means. Participants practicing with an external focus made slightly more shots than those practicing with an internal focus. For reasons similar to those noted above, a one-tailed t -test was utilized. Again, this difference does not reach significance, $t(99) = -0.983$, $p = .164$.

Table 4

Descriptive Statistics of External vs. Internal Focusing Strategy During Phase 2 (25 Shots Each Strategy)

Instructed Focus	n	Statistic	
		Mean	SD
Internal ^a	100	10.92	5.00
External ^b	100	11.30	5.63

Note. The experimenter instructed subjects to take their 50 training shots in the following order: 10 internal, 10 external, 15 internal, and finally 15 external.

^aInternal = 25 shots taken with an internal focus

^bExternal = 25 shots taken with an external focus

Although neither breakdown of the experimental phases, covering the first 100 shots, clearly depicts one strategy as superior to the other, there is a very small effect in both breakdowns that fits in the expected direction of favoring the external focus. It may be possible that the effect is not particularly robust and that sample sizes are too small.

Analysis of Prepost × Group Interaction

An a priori hypothesis stated that there would be a difference in the prepost × group interaction. It was expected that a participant's prepost shift would be dependent on the condition they were placed in. We can see from the summary table below that there was, in fact, a prepost × group interaction that was significant, $p = .038$ (see Table 5). Figure 4 clearly depicts the prepost shifts of the four experimental groups (EE, EI, II, and IE).

Table 5

Prepost × Group Effects

Source	df	MS	<i>F</i>	<i>p</i>
Prepost × Group	3	46.104	2.916	.038
Prepost × Group Contrast (EI vs. Others)	1	111.190	7.032	.009
Prepost × Other Groups	2	13.561	0.858	.427
Error	96	15.812		

From Figure 4 below, it can be seen that the prepost shift for EI is not similar to that of the other three experimental groups. For this reason, an analysis subdividing the prepost × group interaction is appropriate. Therefore, the groups' *df* is subdivided into (a) a contrast that compares EI with the average of the other three groups, and (b) the effect among the other three groups themselves. Then, the interaction of each of these subpartitions with prepost is tested. Table 5 reveals that the prepost × contrast interaction is significant at the .01 level ($p = .009$). No interaction appears between the prepost factor

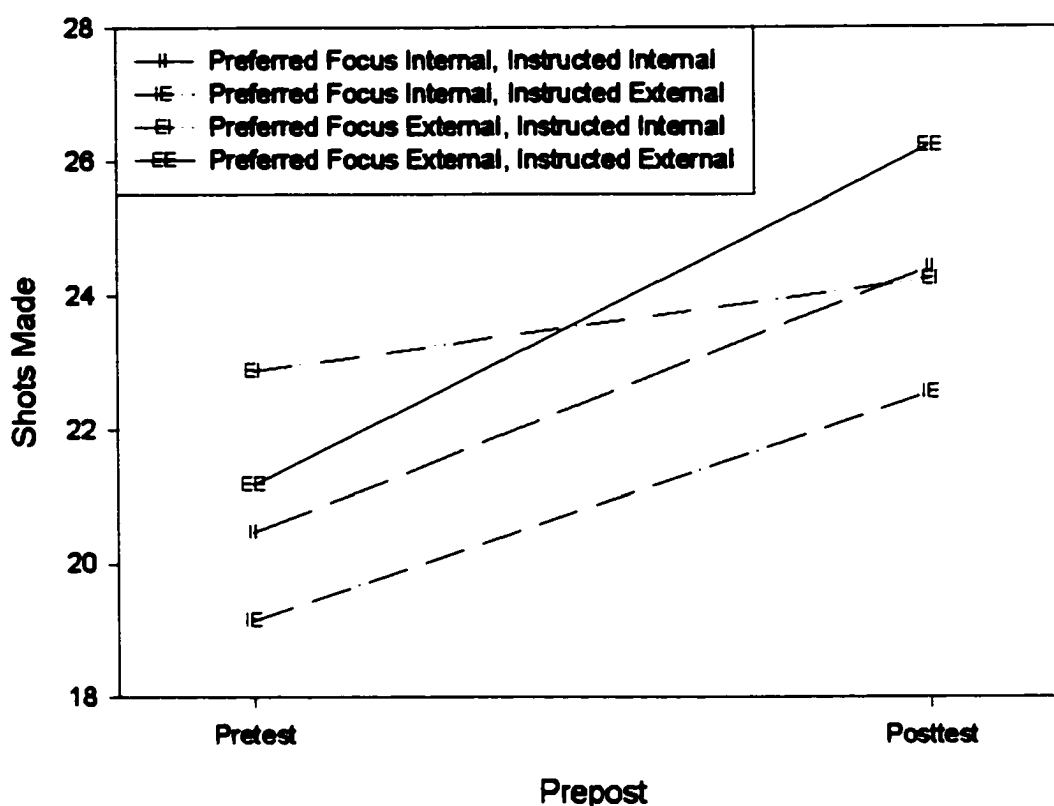


Figure 4. Prepost $\times$ Group interaction.

and the other three groups (EE, II, and IE), $p = .427$. In addition, the parallel lines of these three groups (seen in Figure 4), clearly illustrate that no interaction is taking place. For these reasons, it can be stated that the prepost $\times$ group interaction appears to be resulting from of the EI group alone.

There are possible emotional factors that may have altered performances during Phase 3. What also comes into question is whether an emotional element was present that might influence a participant's performance. Specifically, would it benefit those participants who were allowed to shoot with their preferred focus and/or would it hinder those who were not?

Although, the \$5 prize for significant improvement (15% or better) in itself was probably not a big motivator for most to strive to do their best, it appeared the challenge to reach this improvement level was, in fact, a motivating factor. If we accept this as a true statement, the pressure factor has been successfully integrated into the design. However, because of this imposed stressful situation, the experimental condition the participant was placed in could have further emotional ramifications. For instance, those that are not allowed to shoot the way they prefer may have become upset to the point where a sort of self-fulfilling prophecy may have lead to their failures. Maybe an added degree of stress has been brought upon them by forcing them to change strategies. Some participants visibly showed signs of being upset and others voiced their disappointment in not being able to attempt the final 50 shots in the manner they preferred. On the other hand, if allowed to shoot in their preferred manner, a more positive outlook might have helped them to be successful. Thus, the EE and II groups would have a better chance for success. This may help to explain the surprisingly successful performance of the II group. Despite using an inferior strategy, some people may benefit if simply allowed to shoot in the manner they are most comfortable with. One might also speculate that if you let people shoot the way they prefer to shoot, a heightened self-esteem and thus better performances will result. Although, this is purely conjecture, this too might help to explain the good results produced by the II group. Nevertheless, the findings here support the earlier hypothesis predicting a poorer performance from participants placed in the EI condition.

*Shooting Performances of External-Preferred Focus Group and
Internal-Preferred Focus Group During Phase 2*

For the purposes of this analysis, we are looking back in time to see how individuals performed before they had been assigned to a group. The idea here is to look at those who eventually stated that they preferred either an external or internal focus and see how they performed on the internal and external trials during Phase 2. As far as the design of the experiment is concerned, at this point the notion of being forced to shift strategy has not yet been introduced. Participants at this point have not yet been placed in any group. To accomplish this analysis, we combined the EE and EI groups into an external-preferred group and the II and IE groups into an internal-preferred group.

As the different strategies that were being “taught” to the participants, they were required to alternate between strategies. As noted above, they attempted 10 shots using an internal focus, then 10 shots using an external focus, then 15 shots using an internal focus, and finally the last 15 shots were attempted while using an external focus.

Therefore, rather than analyze this phase as a block of 50 shots, it might make more sense to examine this phase in internal versus external category brackets. In this phase, as far as focus is concerned, a total of 25 shots were attempted using an internal focus and a total of 25 shots were attempted using an external focus. Table 6 displays the descriptive statistics of this breakdown. Table 7 shows that there is a training focus $\times$ preferred focus interaction that is highly significant, $p < .0005$. Figure 5 displays the performances of the groups during phase 2.

From a review of Table 6, the external-preferred group is showing more success on external trials in Phase 2 and the internal-preferred group is showing more success on the

Table 6

Descriptive Statistics of External-Preferred Group vs. Internal-Preferred Group in Phase 2

Preferred Focus	<i>n</i>	Statistic	Training Focus	
			Internal ^a	External ^b
External	54	Mean	10.39	12.74
		SD	4.97	5.67
Internal	46	Mean	11.54	9.61
		SD	5.03	5.17

Note. The experimenter instructed subjects to take their 50 training shots in the following order: 10 internal, 10 external, 15 internal, and finally 15 external.

^aInternal = 25 shots taken with an internal focus

^bExternal = 25 shots taken with an external focus

Table 7

Training Focus × Preferred Focus on Internal and External Trials During Phase 2

Source	df	MS	<i>F</i>	<i>p</i>
Training Focus × Preferred Focus	1	228.220	43.720	.000
Error	98	5.220		

internal trials in Phase 2. Each group is doing significantly better when using the strategy that they will ultimately declare as their favorite (at the beginning of Phase 3). Although, there are several ways to interpret this finding, the possibility exists that participants simply recognized the strategy that led them to the most success. This may have helped them to decide which strategy that they would prefer to use during Phase 3.

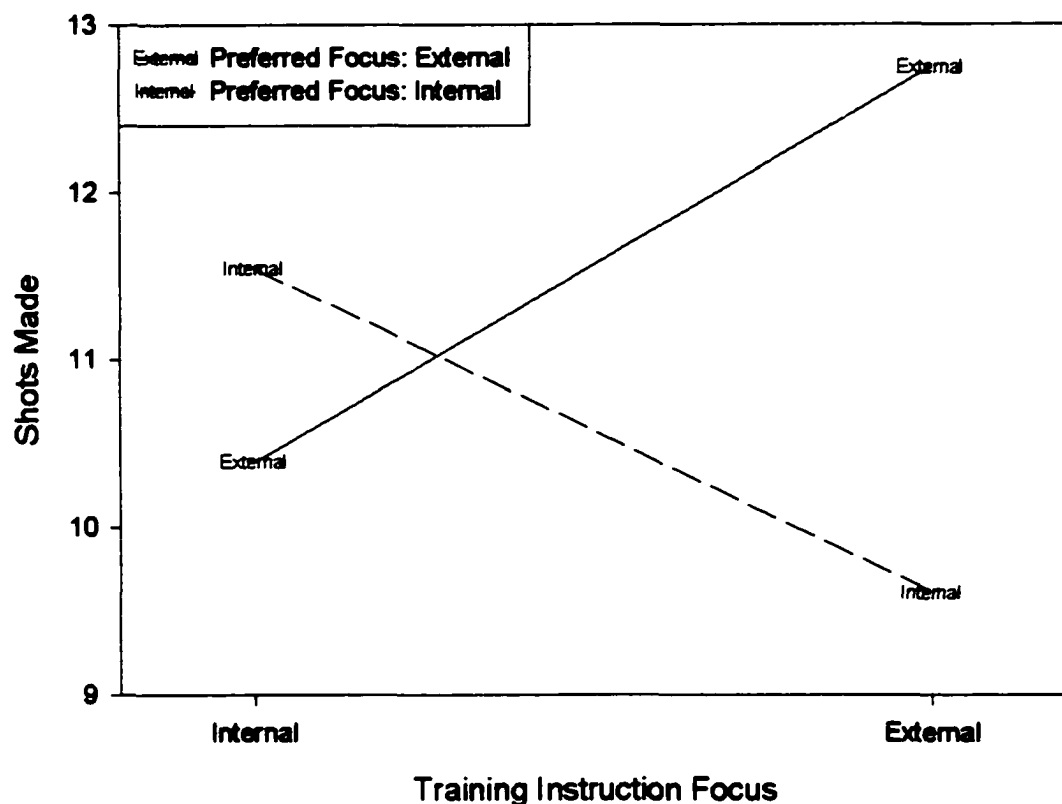


Figure 5. Internal and external training shots (Phase 2) by Preferred Focus.

Reinvestment Scale (RIS) Scores for Preferred Focus and Shifted-Nonshifted Instruction

Upon completion of the free throw shooting task, the final 92 participants tested at the health club facility, answered the Reinvestment Scale (Masters, Polman, & Hammond,

1993). The authors of this scale suggested, “that individuals may have a predisposition for reinvestment of controlled processing, which will lead to skill failure under stress as a result of the disruption of the automatic functioning of the skill” (p. 655). Although, this idea is considered to play a role in performance under pressure, the reinvestment scale was an ingredient included in the present study as a late addition and no hypotheses were made linking this to performance. Masters and his colleagues have presented some evidence to suggest that there may be a personality component that can lead to skill breakdown while a person is attempting complex motor tasks such as the one utilized in the present investigation. Some individuals may have what Masters has referred to as a “predisposition for reinvestment” (p. 655). There appears to be a utility for this scale and future investigations may help to establish if this predisposition belief is real. The data obtained from this part of the study allow for a further test of Masters’ et al. (1993) hypothesis.

An analysis investigated whether participants’ preferred focus or shifted-nonshifted instruction would have any effect on RIS scores. For the purpose of this investigation, shifted-nonshifted instructed focus was broken down into a “stay” or “change” status. Participants allowed to “stay” with their preferred focus were placed in the “stay” condition while those “forced” to change strategies were placed in the “change” condition. The idea here is to see if any of these variables have an effect on RIS scores.

Table 8 displays the descriptive statistics of this breakdown. We can see from the summary table below, that the Preferred Focus × Shifted Focus interaction was not significant, $p = .729$ (see Table 9). As far as their RIS scores are concerned, participants in both the “stay” and “change” conditions were not influenced by their preferred

(external or internal) focus. The parallel lines of these two groups (seen in Figure 6), visibly illustrates that no interaction is taking place.

The ANOVA found that there is a significant main effect for shifting, $p = .008$ (see Table 9). When participants shifted their focusing strategy, they attain relatively high RIS scores. Conversely, when allowed to use their preferred focus, they achieve lower scores. This occurrence is depicted in Figure 6, as the average height of the two lines (change vs. stay), is significantly different. Additionally, the ANOVA found that the main effect for preferred focus was not significant, $p = .527$.

Table 8

RIS Scores $\times$ Preferred Focus and Shifted-Nonshifted Instruction Status

Preferred Focus	Shifted Focus	<i>n</i>	Statistic	
			Mean	SD
External	Stay (EE)	25	8.96	3.02
	Change (EI)	26	11.07	2.91
Internal	Stay (II)	21	8.76	2.68
	Change (IE)	20	10.40	4.42

Note. Participants can achieve a low score on the RIS of zero and a high score of 20.

Table 9

Reinvestment Scores ANOVA for Preferred Focus and Shifted-Nonshifted Instruction

Source	<i>df</i>	MS	<i>F</i>	<i>p</i>
Preferred Focus	1	4.348	.404	.527
Shifted Focus	1	80.078	7.438	.008
Preferred × Shifted	1	1.302	.121	.729
Error	88	10.859		

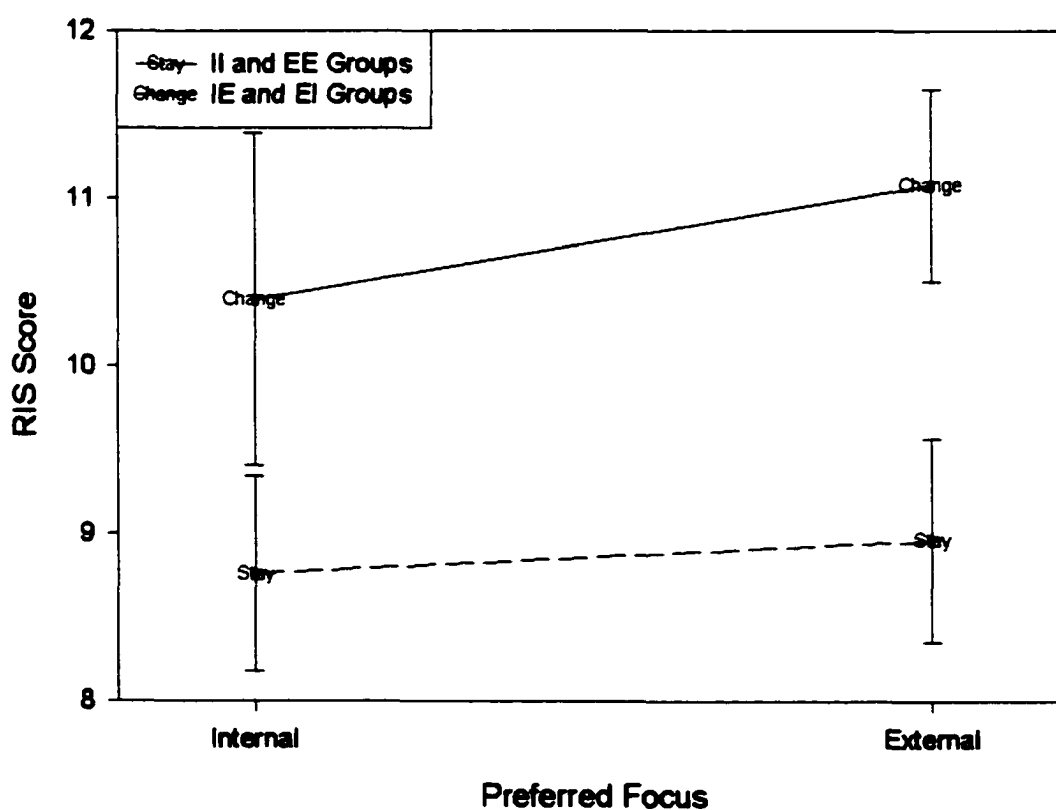


Figure 6. RIS scores for Preferred Focus by shifted-nonshifted Instructed Focus.

Masters et al. (1993) argue that this reinvestment concept should be treated as a dimension of personality. They suggested that some individuals are less able to resist the effects of stress because of their personality type. From a review of Table 8, it can be seen that the EI group scored highest on the RIS. At first glance, this would seem to indicate that these individuals might be best classified as highly self-conscious people. If this were true, it would not be surprising that they are more easily aroused than others during stressful situations. However, there are other reasons that probably come into play that could explain the higher RIS scores for the EI group. Unlike in Masters et al. (1993), the RIS was given after manipulation was carried out. It is very possible that the two groups that were forced to shift strategies were made to be highly self-conscious. For that reason, the data suggest that it is not necessarily a personality type we are dealing with here, but rather, it could simply be a "state of mind" that can be easily manipulated. Those in the EI condition are probably the easiest to manipulate because they are being forced to do something that does not come naturally. Being forced to concentrate on their bodies likely heightens their self-consciousness and hence the reason for the higher RIS scores. As a result, they may have been aroused by the situation of the study rather than because of any personality differences. In this case, what might exist is a situational dimension rather than a personality dimension.

GENERAL CONCLUSIONS

Pertaining to the performance of the four experimental groups during the testing phase, there are significant differences in improvement in the free throw shooting task. There is a strong probability that a natural improvement would take place simply because of a practice or learning. For participants who had never performed this task or had not done so for a long duration of time, you would think that improvement in performance would indeed take place. There seemed to be very little fatigue effects that would counter the practice effect. From a review of the data, what is attention grabbing is that the EI group's improvement in performance was minimal as compared to that of the other three groups. There are several possible reasons that might explain why the EI group's performance in the testing phase did not show the improvement that each of the other three experimental groups did. There may also be an interaction involving these different variables.

The first factor involved is the focus itself. Past research indicates, that an external focus is a more effective strategy to use when attempting a motor skill task (Wulf et al., 1998; Wulf et al., 1998; Wulf, 1999; Wulf, in press). It seems possible that an awareness of one's body movements causes a failure in one's ability to succeed at a complicated task such as shooting a basketball. Since there are several body movements to remember, people are at a high risk for failure because of too much conscious focus on so many elements. Attention on all the different components associated with the skill can be overwhelming for the performer. Too much awareness on body mechanics (internal focus) during the performance of a complex motor skill might actually be damaging.

When looking at the EI groups' failures, speculation is that they were tested while using the 'inferior' internal focus. Further, there is the possibility that the EI group might have been the only group not believing the researcher's claim that the internal strategy "according to past research is the most effective strategy" and would help them to secure the \$5 prize. Perhaps, even a self-fulfilling prophecy was taking place here with this group. A total lack of confidence in the new strategy may have had unfavorable effects on their performance in the shooting task.

To compound the problem of using an inferior focus was the fact that this focus was not an unlearned type. In fact, it was described to the participants most explicitly. The experimenter verbally gave explicit instructions and the technique was explicitly demonstrated. There was very little opportunity for the participants to benefit from implicit learning processes. A cognitive element was present in an explicitly learned strategy.

Rather than explaining why the EI group is not improving, it might be better to explain why the other three groups are improving. This can be argued from the point of view of what may be influencing the success of the other experimental groups. The EE and IE groups are focusing on cues from the external environment. Wulf (1999) mentioned that focusing on "movement effects" (p. 6) might serve to let unconscious control processes take over. Thus, the resultant actions lead to a more efficient performance. It seems that a performer will have more success if he or she can focus on the unpredictable external environment rather than focusing on trying to make their body movements predictable. For example, trying to concentrate on making consistent body movements can sometimes cause the exact opposite to happen (Baumeister, 1984;

Wegner et al., 1998). Therefore, the EE and IE groups are benefiting the most from the instructions given to them. It might be speculated that even though the instructions were initially given in an explicit way, implicit learning is taking place since the focus is now away from the controlled movements and mechanics involved in shooting a basketball. Instead, it appears that unpredictable movement effects should be the focus if one is expected to reach optimal performance levels. Thus, movement effects may be realized in an unconscious or implicit manner.

In much the same way, Singer (1988) recommends that someone's focus should be away from the body and any attention to oneself should be somehow blocked. Singer et al. (1993) use the example of focusing on the seams of a tennis ball while serving as an effective strategy. They conclude there is a better chance to be successful in a motor activity if a person's attention can somehow be diverted away from their body movements. Just as in Reber's early work, where there was an acquisition of complex information without awareness in the artificial grammar studies (Reber, 1967), it seems the same implicit type of learning may be occurring in this complex motor skill. Perhaps, an increased amount of knowledge is being acquired implicitly with every trial when the focus is on the unpredictable movement effects. Thus, the EE and IE groups may have the advantage over the other two groups as far as improving during phase 3 is concerned.

Accepting the assumption that they are using an inferior focusing strategy, it is somewhat puzzling why the II group shows similar gains in prepost test performance scores. One thing that may be of assistance to both EE and II groups has to do with an increased confidence upon hearing that they have chosen the recommended strategy. Despite the possibility that it may be a less effective strategy, the II groups' increased

shooting performances could be attributed to a good mind-set, which is partially compensating for the poor technique they are using. Especially, while under the stress of a pressurized, competitive situation such as the one established in this experiment, these participants seemingly have an advantage in view of the fact that they have been given a mental boost because they selected the preferred method.

Borrowing a phrase from Reber (1993), “the naive view” (p. 113) would be to assume that explicit instructions would benefit performers and thus allowing them to achieve higher successes than the other groups. But, just as Reber and his colleagues found in their artificial grammar learning experiments, sometimes a formal system of learning can be detrimental to performance (Reber, 1967; Reber, 1969; Reber et al., 1980).

It appears, in both the artificial grammar-learning experiments and in experiments involving motor skill tasks such as the one utilized here, that the individual may have already established a mental representation of some sort in an attempt to maximize performance. The layperson might think that a formalized explicit instruction would serve to strengthen this image and further facilitate completing the assignment successfully. Reber et al. (1980) reported that the explicit instructions actually depressed performance. The same occurrence may have taken place in the present experiment. Instructions of this type may cause an overload of conscious processing and thus failure when a complex motor skill task is attempted (Hardy et al, 1996; Masters, 1992; Masters et al., 1993). It seems possible that we have limits to how much explicit knowledge we can use during a stressful situation. The poorer performances of the EI group may have occurred because the instructions were a mixture of explicit and internal focus

instructions. An internal focus seems to deactivate any implicit processes that might have manifested. It might be the case that this type of focusing strategy promotes an excess of conscious processing and thus becomes somewhat counterproductive. These two ingredients independently of one another have been speculated to hamper performance (Masters, 1992; Masters et al., 1993; Reber, 1969; Reber, 1976; Wulf, et al., 1998; Wulf et al., 1999; Wulf, 1999; Wulf et al., in press) Reber, 1989; Reber, 1993, Reber et al., 1980). Explicit and complex instructions requiring an internal focus is probably causing a cognitive element to interfere with the successful completion of this motor skill activity.

Wulf (1999) in a review of several experiments, mentioned that it was “possible that an external focus of attention promotes an implicit mode of motor learning, compared to an internal focus, which perhaps acts to induce explicit learning processes” (p. 6). Schmidt (1982) illustrated this when reporting that skilled pianists will suffer degraded performances after being asked to explicitly describe what motions they are using while playing. This apparently causes the pianist to focus attention on specific hand and finger movements thus leading to detriments in performance. This is similar to what is happening in the present experiment when explicit instructions of an internal nature seem to be causing the most problems for the EI participants.

As noted above, the possibility exists that members of the EI group were provoked to become highly self-conscious individuals because of the manipulation involved. This appears to be the case from data collected from this group’s scores on the RIS, which suggests that these individuals were coerced into being self-conscious because of the set-up of the experimental design. Regardless of any underlying personality, these individuals are acting very self-consciously during phase 3. Since the administration of

this scale was given after the motor skill activity had been completed, it is probably detecting more of a situational dimension than its intended purpose of uncovering a personality dimension. There is little doubt that it influenced participants' answers on the scale.

Interestingly, the IE group also had inflated RIS scores. Evidently, the manipulation made all participants who shifted strategies highly self-conscious. A natural entailment of the pattern of results in both sensorimotor performance and RIS scores is that participants who were overly self-conscious during Phase 3 will only be successful in their motoric performance when they are using automatic processes. This explains why the IE group was successful during phase 3. Unlike their EI counterparts, members of the IE group were using the superior external strategy. Although, manipulated to be self-conscious, possibly they succeeded because they had not been overloaded with very technical rules as those in the EI group were. Perhaps, when put in situations of stress we thrive on automatic processes to bring us success. When consciously attending to remote details we are forced to rely on processes that are not efficient. Often, these situations can cause interference and the person relying on explicit learning probably is not able to effectively understand the rules involved in successfully completing the task.

Arguably the factor that most negatively influenced the performance of the EI group was the "forced" usage of a strategy they did not want to use. This novel component of the methodology of this experiment appeared to temporarily alter the emotional state of participants placed in this condition. They acted in an uneasy fashion and they verbalized their reluctance to change. Apparently, while it contributed to their downfall, it did seem to affect the other group put in a "forced-opposite" condition. The

IE group effectively used their new focusing strategy to achieve significant performance gains in phase 3. This finding strongly supports those theorists advocating an external focus as a superior strategy that promotes implicit learning processes.

All factors noted above combined to bring down the scores of the EI group. One or more of these factors were present in the other experimental groups as well but not these intertwining reasons. The other three experimental groups' performances during the test phase look similar. They show an increase in performance that is above that of the EI group. The other three groups were not subjected to all the adverse situations described previously.

FUTURE RECOMMENDATIONS AND PRACTICAL IMPLICATIONS

The practical implications concerning the enhancement of performance in athletic events is a somewhat curious one. Some coaches' stress the "mechanics" involved in a particular event. The importance of such is not disputed here. The way they are acquired might be. Clearly, when an elite athlete such as Chuck Knoblauch of the New York Yankees' Major League Baseball team cannot make a successful ten-foot throw to get a base runner out there is much more to the problem than his mechanics. It is a mental component that is involved and although a study such as this one may only bring about the smallest of breakthroughs, this could be the edge that makes a difference.

Walker (1999) reported that Knoblauch made 26 errors during the 1999 Major League Baseball regular season, the most by a second baseman. Fourteen of these were on throws and that number could have been much higher if not for some excellent plays by first baseman Tino Martinez who was able to flag down numerous errant tosses from Knoblauch. The intriguing thing about Knoblauch is that just two years before his throwing problems surfaced, he was voted the best fielder at his position when he won the Gold Glove award after the 1997 season. Walker (1999) pointed out that while participating in the 1999 World Series versus the Atlanta Braves, Knoblauch spent part of a workout looking for Steve Sax, a former player who was now working as a commentator for Fox Sports. Sax experienced similar throwing problems during portions of his playing career. Maybe it was a good thing for the current player that he couldn't locate the former one. Walker (1999) quoted Sax as offering this advice, "it's a matter of eliminating all possibility of error as far as mechanics go." Presumably, Sax is from the

“old school” of thought, and that an elite player should go back to an earlier stage and work on the basics.

The above-mentioned problems afflicting today’s players are not new. Unfortunately, to date there have been few successful remedies found to help these individuals. Steve Blass of the Pittsburgh Pirates was a fully established major league pitcher with a reasonably long record of achievement and generally had good control of his pitches. In fact, he won the seventh game of the 1971 World Series and went on to enjoy his best season in 1972. He finished that year with a career best 19-8 won-loss record and an earned run average (ERA) of 2.49. Then, in 1973, without warning, Blass endured agonizing difficulty throwing strikes. His performance that year was inconceivable for such a well-proven athlete. That year he posted a 3-9 won-loss record, 9.85 ERA and perhaps most alarmingly, gave up 84 walks in 88 innings. This situation worsened the following year after being demoted to the minor leagues when he walked 93 batters in just 56 innings. The year after that he pitched what would turn out to be his final inning of in a major league uniform. During a spring training game, Blass walked 8 batters in that fateful inning. Shortly afterwards he retired from baseball because of what has since been commonly referred to as “Steve Blass” disease. Similarly, Rick Ankiel, also a major league baseball pitcher, mysteriously lost the strike zone during the 2000 playoffs and has since been demoted to the minor leagues where many of his throws have been sailing as much as ten feet or more over the intended target. This occurrence has taken place at such a frequent pace that Ankiel, who scouts had labeled as a future superstar, now finds his career is in jeopardy. For many of these players, performance appears to be related to a mental component or loss of focus (O’Keeffe, 1999).

It's actually not very surprising that this "Steve Blass" disease exists. Considering the amazing pressures involved in athletics today, it's probably surprising that it doesn't happen more often. Usually, thousands of spectators' eyes are focused on an athlete, whose every move is analyzed by a horde of media personnel with the hopes of an entire city often riding on their shoulders. There is a good chance that the performer will be guilty of over-thinking when subjected to these heightened pressures. A heightened self-awareness will sometimes cause paradoxical effects commonly referred to as an athlete "choking" under pressure (Lewis et al., 1997).

This research indicates, that Knoblauch's problems and those like professional basketball player Shaquille O'Neal's are likely associated with a breakdown in automatic processes. The methods used to rectify their problems have often included the additions of more explicit and internal type instructions. Instructors appear overly concerned about tracing problems to physical imperfections. As was seen in this experiment, this can lead to more conscious and self-conscious problems. Too much self-awareness is not an ingredient that is going to help these athletes. Of course, it would not be correct to ignore obvious flaws in an athlete's technique. Addressing both the physical and mental aspects is recommended. A blend of both is optimal. Clearly, you have to be able to perform the right movements if you are to be successful. There are simply better ways to holding a golf club or shooting a basketball. That is not in dispute here. But, after the basic movements have been learned, when the behaviors should now become automatic and unthinking is where some athletes' troubles surface.

Buonomano and Merzenich (1998) presented a model of learning that has been very effective in helping children with learning disabilities. The model proposes that the

portion of the brain that controls movement is very reactive, and as the body learns new skills it adapts very quickly to allow the skill to become a habit. Basically, the premise is that as new skills are learned, the brain essentially rewires some of its internal connections to create a sort of cognitive map. So, if this theory is correct, then maybe after practicing a motor skill activity the “rewiring” allows for an implicit knowledge of what to do the next time. It could be further speculated that this implicit knowledge then leads to an expert performance by the athlete. Certainly, there are many cases when a coach might become unsure as to what methods of instruction to employ to improve an athlete’s technical skills. If there is a malfunction in the learned skills of an athlete, the coach will often revert back to the fundamentals (as was the case with Knoblauch). But, maybe, this fails because the internal brain connections have been rewired. Maybe, bringing the focus back to the body is now completely detrimental and actually worsens an already bad situation (again, as is the case with Knoblauch). In the current study, we may have witnessed this when forcing the EI group to try a strategy that may be counterproductive because we were forcing them back to a more primitive stage of development. Consciously or unconsciously, it appears that these individuals were at least somewhat antagonized by instructions that they apparently did not fully accept. The outward appearances of the participants would lead an observer to believe that they were attempting to incorporate the new strategy. However, this usage did not lead to success. Maybe something internally was fighting against these archaic instructions.

Possibly, some athletes understand this idea better than their coaches. Barkow (1998) reported that Ben Crenshaw, the former professional golf great, may have shown an insight into this phenomenon when he mentioned that when you are playing poorly

sometimes you simply need to just try to do the best you can “until the goods come back” (p. C5). Mike Hampton, an all-star pitcher for Houston in 1999, began the 2000 baseball season for his new team, the New York Mets, in a horrible slump. His usual pitching accuracy had seemingly disappeared. After, finally regaining his all-star form, he mentioned that he found success again because he stopped worrying about mechanics and just started going after the batter (“Harmony, unity still elusive goals,” 2000). In both of the above instances, the athlete appeared to abandon the internal focus (mechanics) and instead started concentrating in an implicit way on the movement effects. It seems that in most cases, a player’s “slump” can be worked out through some natural progression. Unfortunately, many coaches will try to get players to regress back to an internal focus and this can be disastrous. The findings of this investigation support the theory that coaches should be careful to phrase instructions in such a way so that they are directing the individual’s attention to the effect of their movements (Singer et al., 1993; Wulf, 1999). The effects that they are focusing on can be real or imagined (Hardy et al., 1996) but focus should be away from one’s body. Although some respected coaches, such as Buzz Braman who attempted to correct Shaquille O’Neal’s foul shooting miseries (“Rebuilding Shaq,” 1994), say that an athlete’s slump will usually occur because of a physical problem; evidence from this study presents a case against this notion.

What is being proposed here in the present study is an alternative to the old-school approaches that seem to be ineffective for certain individuals. Reber and his colleagues have suggested that under the appropriate circumstances implicit learning processes could be more effective than explicit learning processes. Masters and Wulf and their colleagues have applied some of these same ideas in their experiments. The present

study has expanded on these ideas and hopefully has added some insight into this ongoing investigation.

There were certain limitations inherent to this study that should be addressed in future investigations. A practice effect may have been present, which caused each of the four experimental groups to show increases in their performance during the testing phase. Since there was no attempt to determine a participant's previous basketball playing experience one can only guess what effect 100 practice shots might have had. Someone who hasn't ever touched a basketball will likely show great gains regardless of the manipulations of the researcher. Also, because there was no attempt to distinguish between athletes and non-athletes there exists the possibility that one group more than the others might have been overloaded with good shooters. This problem was partially rectified by the fact that each participant was being graded on a comparison score and not a raw score. Nevertheless, it is recommended that future studies address this issue.

Future studies might attempt to further develop a controlled laboratory setting that would possibly be different than the current investigation use of open area gymnasiums. It might be desirable to have internal focus participants surrounded by mirrors while performing a motor skill task. This might accentuate the internalized component. The external group would be tested in an environment void of mirrors thus allowing for no examination of their bodies. Additionally, it might be interesting to closer examine why there might be an increased effectiveness of the external focus. For example, does it matter how far from the body the external focus is? In the present experiment, participants were told to focus on anything in the external environment that was located away from their bodies. Maybe more specific instructions, with a focus that varies in

distance from the participant, might find significant differences as well. Also, an attempt might be made to determine whether it is more important to have an external focus or it is more important not to have an internal focus.

Future studies will hopefully uncover other findings that can be applied to those that may have the physical ability to succeed in athletics and yet fail to do so because they have certain psychological barriers. Additionally, these newer methods of teaching might be applied to other populations as well. Such populations might include motor learning among children, rehabilitating nursing home patients, and possibly even the military might benefit from external focus/implicit learning processes. It appears that researchers have only scratched the surface of investigation into the connection these processes have with those in the sensorimotor learning domain.

APPENDIX A

Reinvestment Scale

REINVESTMENT SCALE

Age _____ Sex _____

Please answer “yes” or “no” to each of the following questions:

1. I remember things that upset me or make me angry for a long time afterwards
2. I get “worked up” just thinking about things that have upset me in the past.....
3. I often find myself thinking over and over about things that have made me angry
4. I think about ways of getting back at people who have made me angry long afterwards..
5. I never forget people making me angry or upset, even about small things
6. When I am reminded of my past failures, I feel as if they are happening all over again ..
7. I worry less about the future than most people I know
8. I’m always trying to figure myself out
9. I reflect about myself a lot
10. I’m constantly examining my motives
11. I sometimes have the feeling that I’m off somewhere watching myself
12. I’m alert to changes in my mood.....
13. I’m aware of the way my mind works when I work through a problem
14. I’m concerned about my style of doing things.....
15. I’m concerned about the way I present myself.....
16. I’m self-conscious about the way I look.....
17. I usually worry about making a good impression
18. One of the last things I do before leaving my house is look in the mirror
19. I’m concerned about what other people think about me.....
20. Do you have trouble making up your mind?.....

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