AN INVESTIGATION OF ATTENTIONAL FOCUS ON BASEBALL BATTING PERFORMANCE IN A LIVE ENVIRONMENT

A Thesis

Presented to the faculty of the Department of Kinesiology and Health Science

California State University, Sacramento

Submitted in partial satisfaction of the requirements for the degree of

MASTER OF SCIENCE

in

Kinesiology

(Movement Studies)

by

Timothy Reid Fitzgerald

SUMMER
2015
AN INVESTIGATION OF ATTENTIONAL FOCUS ON BASEBALL BATTING PERFORMANCE IN A LIVE ENVIRONMENT

A Thesis

by

Timothy Reid Fitzgerald

Approved by:

__________________________, Committee Chair
Dr. Michael Wright

__________________________, Second Reader
Dr. Rodney Imamura

__________________________
Date
Student:  Timothy Reid Fitzgerald

I certify that this student has met the requirements for format contained in the University format manual, and that this thesis is suitable for shelving in the Library and credit is to be awarded for the thesis.

______________________________  ______________________________
Dr. Steven Gray               Date

Department of Kinesiology and Health Science
Abstract

of

AN INVESTIGATION OF THE EFFECTS ON ATTENTIONAL FOCUS ON BASEBALL BATTING PERFORMANCE IN A LIVE ENVIRONMENT

by

Timothy Reid Fitzgerald

The purpose of the study was to test the effects of attentional focus on baseball batting performance against real live pitching using highly skilled batters. Many sport performance researchers have been intrigued by the underlying variables that influence the motor learning process and performance. Since the findings of the first study (Wulf, Höß, & Prinz, 1998) showing the differential effects in external versus internal foci on learning, empirical evidence has amassed for the benefits of adopting an external focus on the intended movement effect relative to an internal focus on body movements (Wulf, 2012). Addressing the question where should highly skilled baseball batters focus their attention while batting, Castaneda and Gray concluded that directing attention to the ball leaving the bat after swing execution results in optimal performance for highly skilled baseball batters (2007). However further research was needed to test these results for sport application.

The current study was designed to test the effects of attentional focus on highly skilled batters in a real baseball environment. Participants (14 males, ages 18-25) were randomly selected into two groups, an experimental and a control group. They were instructed to hit baseballs thrown by the batting practice pitcher into the field of play as
they would in a game. After the pretest, batting performance scores were regressed to ensure the groups were not statistically significant at the start of the experiment. Before the posttest, both groups took part in an attentional focus intervention, however the experimental group’s intervention was highlighted with external focus instructions and the control was given only facilitation instructions. The following week of the intervention, both groups performed the same exercise as the pretest.

It was hypothesized that (1) the mean of the experimental group’s score of quality hits compared to the mean of the control group’s score of quality hits following the posttest, (2) the mean of the experimental group’s posttest score of quality hits compared to the mean of the experimental group’s score of quality hits, or the effect external focus intervention protocol administered to the experimental group, would be statistically significant at an alpha level of .05. After the posttest, the standard t-test gave a p-value of .06 between the means of the experimental group’s posttest score and the control group’s score. The second t-test gave a p-value of .11 between the means of the experimental group’s pretest and posttest scores. Both hypotheses were rejected as written however, the research data demonstrated positively trending results that could be significant in future research studies.

_______________________, Committee Chair
Dr. Michael Wright

_______________________
Date
ACKNOWLEDGEMENTS

I would like to take this opportunity to thank those whom have guided, influenced, and encouraged me along this process in academia. First, I would like thank my family for their continuous unconditional love and support. Without you, none of my life’s achievements would have been possible. Thank you to the coaches, mentors, teachers, and friends that have encouraged my journey and the pursuit of my goals. I would like to thank my graduate school advisor/mentor, Dr. Michael Wright, for his patience, guidance, and instruction which has had a profound effect on the development of my academic and professional goals.
TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acknowledgments</td>
<td>vi</td>
</tr>
<tr>
<td>List of Tables</td>
<td>ix</td>
</tr>
<tr>
<td>List of Figures</td>
<td>x</td>
</tr>
<tr>
<td>1. INTRODUCTION</td>
<td>1</td>
</tr>
<tr>
<td>Statement of the Problem</td>
<td>3</td>
</tr>
<tr>
<td>Purpose of the Study</td>
<td>3</td>
</tr>
<tr>
<td>Hypothesis</td>
<td>4</td>
</tr>
<tr>
<td>Assumptions</td>
<td>4</td>
</tr>
<tr>
<td>Delimitations</td>
<td>5</td>
</tr>
<tr>
<td>Limitations</td>
<td>6</td>
</tr>
<tr>
<td>Definitions of Terms</td>
<td>6</td>
</tr>
<tr>
<td>2. REVIEW OF LITERATURE</td>
<td>8</td>
</tr>
<tr>
<td>Attentional Focus</td>
<td>8</td>
</tr>
<tr>
<td>The Focus of Attention and Baseball Research</td>
<td>10</td>
</tr>
<tr>
<td>Mental Game of Baseball</td>
<td>12</td>
</tr>
<tr>
<td>Biomechanics of a Baseball Swing</td>
<td>13</td>
</tr>
<tr>
<td>3. METHODS</td>
<td>15</td>
</tr>
<tr>
<td>Participants</td>
<td>15</td>
</tr>
<tr>
<td>Apparatus</td>
<td>17</td>
</tr>
</tbody>
</table>
Procedures and Tasks .........................................................................................18

Pretest ..............................................................................................................18

Intervention ......................................................................................................18

Posttest ............................................................................................................19

Data Collection ..................................................................................................20

Statistical Analysis .............................................................................................20

Timeline of the Experiment ..............................................................................21

4. RESULTS .......................................................................................................22

Data Analysis .....................................................................................................22

5. DISCUSSION ..................................................................................................26

Conclusions and Recommendations for Future Studies .........................27

Works Cited .......................................................................................................37
LIST OF TABLES

Tables                                      Page

1. Comparison of the Means of the Experimental and Control Groups...........................23
2. Results of the Study.................................................................24
3. Experimental Group Means of the Attentional Focus Check ......................................25
<table>
<thead>
<tr>
<th>Figures</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Data Collection Chart</td>
<td>32</td>
</tr>
<tr>
<td>2. Attentional Focus Intervention Protocol</td>
<td>33</td>
</tr>
<tr>
<td>3. Attentional Focus Check</td>
<td>35</td>
</tr>
<tr>
<td>4. Overview of Apparatus</td>
<td>36</td>
</tr>
</tbody>
</table>
Chapter 1

INTRODUCTION

Motor skill researchers, coaches, and performers continually investigate different ways to better facilitate skill acquisition and the optimization of performance in their given domain. Skilled performance is characterized by high levels of movement effectiveness and efficiency. That is, a high level of skill is associated with accuracy, consistency, and reliability in achieving the movement goal, i.e. effectiveness, (Wulf, Höß, & Prinz 1998; Shea & Wulf, 1999; Wulf, McNevin, & Shea, 2001; Wulf, 2007a, 2007b), as well as fluent and economical movement executions and automaticity, as evidenced by the investment of relatively little physical and mental effort, i.e. efficiency (Lohse, Sherwood, & Healy, 2010; Lohse & Sherwood, 2011; Lohse, Wulf, & Lewthwaite, 2012). Numerous research studies on attentional focus have consistently shown that adopting an external focus (i.e., the effect of our movement on the environment) versus an internal focus (i.e., associated with the body) of attention speeds up the learning process allowing for a higher level of skill, is achieved at a more rapid rate (Lohse, Wulf & Lewthwaite, 2012; Marchant, 2011; Wulf, 2013).

Extending attentional focus sport application research, Castaneda and Gray (2007) proposed the question of where baseball batters should focus their attention while batting. Their research concluded that the optimal focus of attention for highly skilled batters was one that does not disrupt proceduralized knowledge and permits attention to the perceptual effect of the action. That is, experts must direct their focus to the ball leaving the bat after swing execution to optimize performance. This conclusion was consistent
with Prinz’s common-coding theory (1990, 1997), first demonstrated by Wulf and colleagues (1998, 2001), which states that actions are coded in terms of the perceivable environmental effects the actions should generate (Castaneda and Gray, 2007). If one’s actions are commonly coded in terms of the perceivable effects, then attending the perceptual effect or outcome of one’s actions should strengthen this coding allowing for automaticity (movement actions to be uninhibited, relatively unconscious, fast, and reflexive until after the action is complete) of the motor codes (Wulf, McNevin, & Shea, 2001; Wulf, Shea, & Park, 2001). The study also gave strength to the “constrained-action hypothesis”, postulated by Wulf and colleagues (1998, 2001), which accounts for the relatively inferior acquisition and performance of motor skills, when an attentional focus was directed towards effects in close proximity to the body or towards the body itself (Internal Focus).

The conclusions scientifically backed several theories proposed by baseball coaches and performers, though the previous research was lacking generalizability to the sport application of baseball and additional testing of the effects of attentional focus was needed to strengthen the external validity of the research. For example, the method involved using a batting simulation rather than batters facing real live pitching and seeing flight of the batted balls on an actual field, further research was needed to test these conclusions (Fortenbaugh, 2011). Coaching literature emphasized that hitting against live pitching is ideal for because it most accurately represents game situations (Robson, 2003).
Statement of the Problem

Further research was needed to examine some important limitations in the research done by Castaneda and Gray (2007), and other studies conducted by Gray (2002a, 2002b, 2004, 2009a, 2009b, 2010, 2013) and colleagues (Gray, Beilock, & Carr, 2007; Scott & Gray, 2010; Gray & Beilock, 2011). These limitations included the use of a baseball batting video simulation in a laboratory setting using the mean temporal error of as a measure of good external validity. Participants swung a sensor-mounted little league bat at a simulation projected of a pitcher throwing a baseball at various speeds, 30 to 40m/s (67-90 mph) with similar heights accounting only for the drop of gravity during ball flight which still gave a large variation in height of the pitched balls. All pitches thrown from the simulation were also strikes thrown down the middle of the plate. These limitations did not account for the variability that is seen in a real live baseball environment, such as batters using regulation baseball bats and hitting real baseballs. Conducting further research to test the effects of attentional focus on baseball batting performance in real baseball environment, would add external validity to the conclusions of Castaneda and Gray (2007), as well as extend the research field on attentional focus sport application.

Purpose of the Study

The purpose of this study was to test the effects of attentional focus on the baseball batting performance of highly skilled batters in a real baseball environment using live pitching.
**Hypothesis**

The research hypotheses of the study were as follows: (1) Highly-skilled batters implementing an external focus of attention, attending to the ball leaving the bat after swing completion (experimental group), would be statistically significant at an alpha level of .05 in the means of quality hits compared to the mean of quality hits of the control group during the performance phase of the experiment. (2) The experimental group’s mean of quality hits of the posttest would be statistically significant at an alpha level of .05 compared to the experimental group’s mean of quality hits of the pretest, thus testing the effect of the external focus of attention intervention.

**Assumptions**

There was an underlying assumption that baseball batting research was important enough to the general public to conduct research and make generalizations about the findings. It was assumed that the participants selected for this research experiment were representative of the population being tested. Previous research sample inclusion/exclusion criteria were included when selecting participants regarding this select population sample. It was assumed that the participants would adhere to the verbal instructions and directions administered to them during the study. Since a mixed-method paradigm was chosen to test the effects of attentional focus, it was assumed that the integration of the qualitative and quantitative traditions would complement each other to generate the best supportive evidence to draw conclusions and make decisions (Greene and Caracelli, 2003).
Delimitations

My research study was delimited by the sample I have chosen. The sample was suggested to be generalizable to highly-skilled baseball players. The sample had inclusion criteria of males, ages 18-25, physically fit, current college baseball player, with at least six years of playing experience, and played competitively in the last year. Excluded from the study were females, minors, and less-skilled baseball batters but, these other research populations may be possible in the future. All participants were recruited from the Sacramento region of California where the study took place. Another delimitation to the research study was the experimental design. It contained two groups, external focus of attention (experimental) and no feedback/instruction (control). An internal focus of attention group was negated from the experiment because previous research (Castaneda and Gray, 2007) had already concluded internal focus of attention degraded performance in highly skilled batters.

The spray chart was designed to measure quality hits on a baseball field. Since certain research materials or data collection tools were not available, batted balls hit under the given definition of a quality hit would be sufficient for anyone, in or out of the baseball world, to agree upon. Data from previous spray charts of batted balls were used to formulate the definition based on Major League Baseball games in the 2008 season (Fast, 2011), and flight times of fly balls taken from major league sabermetric data of the 2013 season (Zimmerman, 2014). Pilot data was analyzed to tweak these parameters and to test their reliability for the sample population. This definition and its parameters should be changed for different populations in future research studies.
Limitations

Since the research experiment was performed outside of a laboratory setting, the weather could have directly affected the ball flight of the pitch, flight of the batted ball, and the participants’ performance during the experiment. The batting practice pitcher was a limitation to study due to the inaccuracies of human movement, however the hitters were told to look for pitches they would swing at in 2-0 and 3-1 counts, which had been shown to be the best counts for batting performance (Gray, 2002). More advanced data collection apparatuses could provide more insight into the data however these materials were not obtainable. The research study was limited by the timetable granted to the primary researcher to complete the experiment.

Definitions of Terms

Proceduralized Knowledge – Knowledge of how to do an action by long term practice and countless repetitions which can function largely without the assistance of working memory or conscious attention.

Distal Events – events or goals that the participant is trying to accomplish prior to skill execution.

Constrained-Action Hypothesis – Performers utilizing an internal focus of attention tend to interfere with automatic control processes that would normally regulate the movement, whereas an external focus of attention allows the motor system to more naturally self-organize.
Attentional Focus – The point of focus for an individual’s concentration of a specific aspect of his or her movements (internal) or of the environment (external).

Internal Focus of Attention – Attention to the movement of part of one’s body during skill execution.

External Focus of Attention – Attention is directed to the effect one’s body movement has on the external environment.

Quality Hit – A ball hit in the air well enough to reach a minimum Zone 2 but must roll into the outfield, batted balls hit into the outfield (Zone 3) must have a ball flight less than 3.00 seconds, and batted balls hit deep into the outfield beyond 300 feet (Zone 4) are considered to be of quality. (See Figure 1 for further explanation)
Chapter 2

REVIEW OF LITERATURE

The previous literature involving baseball batting has generally been split into two distinct categories: coaching of the skill and the scientific research backing these claims. However, more recent studies have merged the research linking what coaches should teach and what scientists could measure (Fortenbaugh, 2011). The first section of this literature review introduces the foundational work of the attentional focus research primarily investigated by Wulf and its current conclusions regarding its effects on motor movement and performance (Wulf, 2013). The second section focuses on the research of Castaneda and Gray (2007) to chronologically lead the research of attentional focus into the current study. The third section examines additional views of baseball batter’s focus of attention during performance. The fourth and final section concludes the review and demonstrates how the study was linked to the previous research.

Attentional Focus

An important theoretical approach of motor skill learning and performance enrichment had been to consider the learner or participant’s focus of attention and the underlying mechanisms that relate to the effects. One type of attentional focus had consistently demonstrated to enhance the learning across a variety of skills, levels of expertise, and age groups. An external focus of attention (concentrating on the movement effect) has shown to be superior on the performance and learning of motor skills compared to an internal focus of attention (concentrating on one’s body
movements) (Wulf, 2013). These findings have important implications for practical settings, where a speedy, cost effective, and time efficient acquisition, retention, and transfer process, is necessary (Wulf, 2007).

Since the first study demonstrating the differential effects of external versus internal foci on learning (Wulf, Höß, & Prinz, 1998), many studies have followed culminating in an extensive literature supporting the benefits of adopting an external focus of attention versus an internal focus. The first explanations for this theory referred to Prinz’s common coding theory, conceptualizing the relationship between perception and action. Prinz (1990) suggested that we perceive and plan our actions in terms of distal events (i.e. the intended outcome of one’s actions). Even though the consistent benefits associated with an external focus are in line with this theory, it did not specifically predict the differential learning effects of external versus internal attentional foci (Wulf & Prinz, 2001)

To address these concerns of the evolving theory, Wulf, McNevin, and Shea (2001) postulated that the advantages associated with external focus of attention arise as a consequence of the utilization of more “natural control mechanisms”. This postulate led to the formation of the constrained action hypothesis, which proposes that individuals who direct their attention internally during skill execution interfere with automatic control processes that would normally regulate the movement. In contrast, focusing on the movement effect has been shown to promote use of automatic processes, which results in more effective performance and learning (Wulf et al., 2001). There are several lines of evidence in support of the constrained action hypothesis including
demonstrations in reduced attentional-capacity demands (Wulf, McNevin, & Shea, 2001),
and high frequency movement adjustments (e.g., McNevin et al., 2003; Wulf, Shea, &
Park, 2001). Higher frequency adjustments are reflective of faster reflex loops, and
increase in active degrees of freedom, and more automated, effective and efficient

The Focus of Attention and Baseball Research

Dr. Rob Gray has extensively researched the cognitive processes of baseball
batters including, a model of batter precognitive processing in batters (2002); attentional
focus during skill execution in expert and novice batters (2004); effects of focus of
attentional focus during batting performance (Castaneda & Gray, 2007); batter outcome
predictability (Gray, Beilock, & Carr, 2007), motor inhibition of baseball batters (2009a);
the use of visual, auditory, and tactical information about successful baseball swings
(2009b); sensitivity in making swing decisions in experts and novices (2010); action
induction effects in baseball batters (Gray & Beilock, 2011), comparison of the effects of
imagery and action observation on hitting performance (Nueman & Gray, 2013); and
perception variables relating to hitting goals and performance (2013). These studies have
solidified a solid ground work to cognitive processes involved in a complex motor skill
such as baseball batting.

To address the question of what baseball players should focus their attention on
while batting, Castaneda and Gray investigated two comparisons between attentional foci
in which skill vs. environment and internal vs. external can account for different
performance outcomes. The researchers used eight less-skilled (not currently playing college baseball) and eight highly skilled (active college team participants) baseball players participating in four dual task conditions in a baseball batting simulation: two tasks that directed attention to the execution of the skill (skill/internal, skill/external), and two that directed attention to the environment (environment/external, environment/irrelevant). Using a modified version of the simulation used in the previous Gray studies (Gray, 2002a, 2002b, 2004), the participants swung a sensor-mounted little league size bat at a simulation of a pitcher throwing a baseball at various speeds, 30 to 40m/s (67-90 mph) with similar heights accounting only for the drop of gravity during ball flight, which still gave a variation in height of the pitched balls. All pitches thrown from the simulation were also strikes thrown down the middle of the plate for each trial. Their research concluded that the optimal focus of attention for highly skilled batters was one that does not disrupt proceduralized knowledge and permits attention to the perceptual effect of the action. That is, to optimize performance, experts must focus their attention to the ball leaving the bat after swing execution (Castaneda and Gray, 2007).

This effect, as first discussed by Wulf and colleagues (reviewed in Wulf and Prinz, 2001), was consistent with the common-coding theory of perception and action (Prinz, 1990) as the optimal batters (environmental/external) were perceivably able to strengthen the connection. However Castaneda and Gray (2007) suggested future research should include balls and strikes into the method in order to confirm the optimal attentional focus for highly skilled baseball batters.
Mental Game of Baseball

Since the birth of baseball, a player’s mental ability has been recognized as an important criterion to playing at a high level as well as an area of focus for hitters and coaches looking to optimize performance at the plate. Dorfman and Kuehl (2002) recommend that a hitter’s sequence of thoughts may vary slightly, but should establish a consistent pattern for performance enhancement while batting. They suggest nine steps in the pattern: seven before the pitch and two steps after the swing/no swing reaction of the incoming pitch. First, it was recommended that the hitter must look at the situations on the field (Broad External Focus). Next, the batter’s focus switches to look for the signs from the coach (Narrow External Focus). The hitter must analyze the situation (Broad Internal Focus) then plan and visualize what was to be done in the given game situation (Narrow Internal Focus). The batter steps into the batter’s box and gets comfortable before the umpire puts the ball in play (Mental Break). The hitter must monitor their breathing levels, tension, and let go of all anxiety (Narrow Internal Focus). Finally before the pitch, the hitter must turn over to an “automatic guidance system” using the eyes (Narrow External Focus).

According to Dorfman and Kuehl, hitting is an external function and thinking is an internal function. When a hitter tries to handle more than one function at a time, the attention becomes divided and the message from the eyes will not be clear. The guidance system needs a clear channel to do its job (2002). This combination of external and internal focus was not suggested by Wulf and other researchers due to the mentally constraining effects of switching between foci on the participants during skill execution.
which may hinder performance clogging up the way for our motor movements to effectively operate (Wulf, 2013). However, the last step of the mental prep (the automatic guidance system) explained above, was congruent with the constrained action hypothesis postulated by Wulf, McNevin, and Shea (2001) which described “natural control mechanisms” allowing for more automated procedures during motor performance.

**Biomechanics of a Baseball Swing**

The baseball swing has been described as a kinetic transfer of energy from lower body to the upper body to the bat, hoping to impart the maximum amount of energy into the ball. Scientists and coaches have researched and developed theories on the key aspects of a successful baseball swing. The biomechanics of baseball batting was extensively researched establishing a large database of biomechanical parameters on successful baseball swings (Fortenbaugh, 2011). From a purely biomechanical standpoint, some preliminary advice to give to coaches based on this study are to have batters: (a) develop a strong, consistent approach for every swing in the early phases, particularly with the lower body; (b) anticipate a fastball for every pitch, but be able to recognize an off-speed pitch as early as possible; (c) use the powerful rotation of the pelvis to transfer the Ground Reaction Force and help direct the body according to the location of the incoming pitch; and (d) use the upper body to guide the hands along the appropriate path, putting the bat in a strong, properly angled position to direct the ball from its impact location to its desired destination on the field (Fortenbaugh, 2011).
Now combining what has been said about attentional focus, these biomechanical factors should become automatically reproduced by the highly skilled participants. Castaneda and Gray (2007) suggested that less-skilled athletes may improve using an internal focus of attention to perfect the correct form to optimize these biomechanical factors in a baseball swing, however Wulf refuted that claim by explaining that when attentional focus instructions were administered through dual-task situations, in which participants hitting baseballs had to make a judgment regarding the direction of their hands (internal) or the bat (external) were moving when a auditory tone (environment/distal) was presented, the additional demands imposed on novices may cancel out any focus effects (Wulf, 2013).

This primary aim of this research experiment was intended to test the effects of attentional focus on baseball batting performance in an applied setting. However this study also looked to address some underlying issues and concerns regarding attentional focus research and its sport application. According to Wulf, further research was needed to address questions regarding the hierarchy of the distance effect, appropriate attentional focus instructions, pretest/posttest experiments, and manipulation checks among others within the field of attentional focus (2012). Future researchers may consider this study to address questions regarding these matters.
Chapter 3

METHODS

This study was designed to test the effects of attentional focus on baseball batting performance of highly skilled batters using live pitching in an outdoor baseball environment. This experiment’s design was unique in that it was the first of its kind to test the effects of attentional focus of baseball batters using live pitching which was said to be ideal because live pitching most accurately represents game-like conditions (Robson, 2003). Fourteen participants, randomly selected into two groups (experimental and control), took part in a pretest/posttest experiment in which batted ball performance was recorded against live pitching from a batting practice pitcher. Quality hit (QH) scores were recorded as batted balls succeeded or failed to meet the written definition of quality hits. After the pretest, both groups took part in a baseball batting performance intervention, however the intervention sessions with the experimental group were highlighted with external focus directions and feedback, one week before the posttest. The means of the two groups were statistically regressed using standard t-tests, after the pretest and posttest, as well as, a standard t-test to test the significance of the effect of the intervention on the experimental group from pretest to posttest. These standard t-tests tested for significance at an alpha level of .05.

Participants

The participants used in this experiment were 14 male baseball players, 7 in the experimental group, and 7 in the control group (Age, μ=19.8, Years of Experience,
µ=14.6). The subjects were recruited from junior college campuses in the Sacramento, California and surrounding areas. During the experiment, all participants wore shoes or cleats and either gym shorts or baseball pants. Participants were not aware of the aim of study to ensure internal validity of the experiment, only that their batted balls would be recorded on the field for an experiment. Consent forms were signed by each participant before participating in the experiment to ensure all rights and well-being of the participants are protected during and after the experiment. All participants remained confidential throughout the experiment. Each participant was given cold water and Gatorade as compensation for their participation in the experiment.

Every participant, regardless of their group, was informed that the primary objective of the task was to hit the baseball well into the field of play. They were instructed to swing as they normally would in a game situation (2-0, 3-1 counts), which has shown to eliminate much of the hitter’s swing inhibition during swing execution (Gray, 2013). Each participant was randomly selected into the two groups: the experimental group (batters adopting an external focus emphasizing the distal events of the action), and the control group (no feedback/instruction). Immediately following the conclusion of the experimental group’s posttest, a questionnaire was filled out by each participant in the experimental group to ask them what they focused on during each batting session (see figure 3). Their responses were recorded to ensure external focus was being used by the experimental group.
The study took place on a regulation baseball field (see Figure 4). Once groups were randomly selected, both groups participated in a pretest to ensure there is no significance between the groups before the invention has been initiated. Once this important research parameter had been met, the control and experimental groups participated in a baseball workout intervention one week prior to the posttest. The interventions were the same however, the experimental group participated in the training course highlighting how to utilize external focus of attention properly through verbal instruction from the primary researcher. The control group did not receive any focus of attention instructions before or during the intervention, only facilitation directions. On the days of testing, participants were allowed to perform any warm up drills they deem necessary for preparation for the test and to prevent injury.

Instead of using the baseball batting simulation in several past experiments (Gray, 2002a, 2002b, 2004, 2009a, 2009b, 2010, 2012; Castaneda & Gray, 2007; Gray & Beilock, 2011; Gray, Beilock, & Carr, 2007; Scott & Gray, 2010), each participant hit regulation five ounce baseballs thrown by a live pitcher. The pitcher stood on a raised pitching platform, 40 feet from the plate towards the pitching mound, while throwing pitches to the participants. The standard five ounce baseball was thrown from the pitcher standing behind an “L-screen” for protection. The pitcher threw fastballs as close to the center of the plate to decrease the level of variability in the pitches being thrown. Fastballs are the most common pitch thrown in baseball games and pitches down the middle are the most neutral and usually the most desirable for batters (Fortenbaugh,
The batters stood directly in the batter’s box as they would in a game situation. A backstop was present to catch the balls when the batter did not swing. There were no time restrictions between pitches and each participant was allowed as much time in between swings as they need before their execution of the next swing.

Procedures and Tasks

Pretest

After preliminary individual warm up, the participants took part in a one round, ten swings performance phase. The participants hit the pitches thrown by the pitcher (64-66 MPH), from 40 feet away, and scores recorded using a spray chart defining where the ball landed on the field as either ground ball(GB), quality hit(QH), fly ball(FB), not in play(NIP), which includes any foul balls and missed swings, or no swing(NS). If the participant did not swing at the pitch, the participant was given another pitch to hit without any penalty until ten batted balls were recorded each round. Batted balls that hit the L-screen were considered to be “re-dos” as landing distance and flight time could not be accurately measured. Both groups hit on the same day and no feedback was given to them during the pre-test as to their scores overall.

Intervention

Each group participated in the same intervention (see figure 2 for details). Both groups did not participate in the intervention on the same days to ensure that external focus instructions were not accidently inherited by the control group participants. Each
participant was instructed to attend a hitting session before their daily team practice to insure minimal fatigue has transpired before the intervention. During the session, each participant had access to resources helping batter performance such as hitting tees, soft front toss, and live pitching. A minimum of 20 swings, but not more than 100 swings, must be taken by each participant during each session.

During the intervention with the experimental group, verbal instructions on how to utilize external focus during swing execution were introduced to the batters. During this group’s hitting sessions, the participants were instructed to focus their attention to the ball leaving the bat after swing execution. No internal focus instructions were given by the researcher. Immediate results may not be seen, but with two training sessions, twenty four hour apart with another break before the posttest, the intervention should allow for acquisition of external focus of attention to be present (Wulf, Chiviacowsky, et al, 2010; Bell and Hardy, 2009).

**Posttest**

The post-test was the exact same procedure as the pre-test (see Figure 2). Once again, participants were allowed to warm up as they saw fit to prepare for the testing phase. Each participant hit one round, ten recorded swings per round, off live pitching. The experimental group was once more reminded to focus their attention externally (i.e., “While you swing, focus on the ball leaving the bat….”), Only external focus of attention feedback was given, just as they had been instructed during the intervention process. The control group was given no feedback or instruction once again. Each
participant’s scores were recorded on a spray chart (see Figure 1) according to the parameters set during the pre-test. Immediately following each experimental group participant’s performance round,

Data Collection

Data for the study was recorded using a baseball hit/spray chart defining quality hits (QH). Also recorded on the spray chart were groundballs (GB), fly balls (FB), balls not in play (NIP), and no swings (NC). A quality hit was defined as batted balls that travel in the air past zone 1 into zone 2 of the baseball field but must come to rest in zone 3 (outfield grass) (Fast, 2011). Batted balls landing in zone three must not exceed a flight time of three seconds, as this is seen to allow for the most success for line drive to fall for hits (Zimmerman, 2004). Batted balls carrying into zone four do not need to meet the time criteria because balls hit into zone four would be considered well hit (traveling distances of 300+ feet) by most baseball standards for the given sample of participants. This definition was the first of its kind and the parameters were defined in terms for college level athletes. Future researchers should investigate new parameters than the one in the given experiment to account for different populations (i.e. skill level, age, gender, etc.).

Statistical Analysis

After completion of the experiment, the data collected was analyzed using standard t-tests evaluating for significance at an alpha level of .05. Since the population’s
mean and standard deviation were unknown, a standard t-test was used for statistical analysis of the data. The participants were randomly selected into two groups, experimental and control, and were independent of each other. After the pretest, a standard t-test was used to compare the mean scores of the two groups to ensure the groups were not statistically significant at the start of the experiment. After the posttest, another standard t-test was used to compare the means scores of the both groups following the intervention. Finally, a third t-test was used to compare the quality hit mean scores of the experimental group from pretest to posttest, which would test the effect of the intervention had on the group.

Timeline of the Experiment

Week 1: Friday – Pretest of both groups

Week 2: Monday – Control Group Intervention Practice Day 1

Tuesday – Experimental Group Intervention Practice Day 1

Wednesday – Control Group Intervention Practice Day 2

Thursday – Experimental Group Intervention Practice Day 2

Week 3: Monday – Experimental and Control Group Post Test
Chapter 4

RESULTS

Empirical evidence has shown the positive effects of an external focus of attention (i.e. the movement effect on the environment) opposed to an internal (i.e. directing a part of one’s body) focus of attention (Wulf, 2015). Researchers Castaneda and Gray explored the question of where should baseball batters attend their focus to optimize performance. Their results concluded that batters focusing their attention to the ball leaving the bat (external focus) after swing execution would result for better performance (2007). Even though these findings supported theories of Wulf and her colleagues, further research was needed to test the sport performance application of these (Fortenbaugh, 2011). The experiment sought out to add to the amassing evidence of the benefits of external focus of attention and add external validity to these claims concerning highly skilled batting performance.

Data Analysis

A standard t-test was performed for the quality hits recorded during the performance phases of the pre and posttests. After the pretest, the mean of the experimental group’s score of quality hits was 3. The control group’s mean of quality hits per round was 2.29 quality hits (see Table 1). The first t-test was performed with the means experimental and control groups scores to ensure that the groups were not already statistically significant from each other. The calculated p-value between the two
groups was 0.475, inferring that the groups were not already statistically significant at the beginning of the experiment.

*Table 1*

*Comparison of the Means of the Experimental and Control Groups (QHs)*

<table>
<thead>
<tr>
<th></th>
<th>Pretest</th>
<th>Posttest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental</td>
<td>3.0 ± 0.5</td>
<td>5.0 ± 0.6</td>
</tr>
<tr>
<td>Control</td>
<td>2.5 ± 0.4</td>
<td>4.5 ± 0.7</td>
</tr>
</tbody>
</table>

After the posttest, the experimental group scored a mean of 4.57 quality hits during their performance rounds (see Table 1). The control group scored a mean of 3.14 quality hits out the 10 swings attempted in their individual performance rounds. The second t-test was performed to test the significance of the means of the two groups after the intervention had been administered. The calculated p-value between the two groups after the performance phase of the posttest was 0.06, which would infer that the attentional focus intervention did not statistically separate the two groups significantly. This data rejected the first hypothesis.
A third t-test was performed to test significance between the experimental group’s pretest and posttest means of quality hits. The experimental group scored a mean of 3 quality hits after the pretest. The experimental group scored a mean of 4.57 after the posttest. The calculated p-value of the experimental group’s mean of quality hits from the pretest to posttest was 0.11, which also infers that there was not enough difference of means to be statistically significant. This data also rejected the second hypothesis.

Table 2

Results of the Study

<table>
<thead>
<tr>
<th></th>
<th>Mean(µ) of Quality Hits(QH)</th>
<th>P-Value (α)</th>
<th>Statistically Significant (Y/N)</th>
<th>Accept or Reject</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental/Control</td>
<td>3/2.29</td>
<td>0.48</td>
<td>No</td>
<td>Accept</td>
</tr>
<tr>
<td>(Pretest)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experimental/Control</td>
<td>4.57/3.14</td>
<td>0.06</td>
<td>No</td>
<td>Reject</td>
</tr>
<tr>
<td>(Posttest)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pretest/Posttest</td>
<td>3/4.57</td>
<td>0.11</td>
<td>No</td>
<td>Reject</td>
</tr>
<tr>
<td>(Experimental Group)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

After the posttest, the experimental group was asked to report the use of their external focus intervention (see Table 3). Responses to the questions were delivered via the Likert Scale, ranging from 1 (not at all) to 5 (very much so). The purpose of this manipulation check was to ensure that external focus was being utilized and to what extent during the performance phase immediately following the posttest by the experimental group. The experimental group scored a mean of 3 on the first two questions; (1) to what extent were they focused on the movements of any part of their body (internal focus), and (2) to what extent were they focused on the position of the bat while swinging (external focus/proximal). The third question produced the highest mean
of 4.3 when answering to what extent were they focused on the flight of the ball as they executed the swing (external focus/distal). The control group was negated from the attentional focus manipulation check because they were not given any attentional focus instruction at any time during the experiment.

*Table 3*

*Experimental Group Means of the Attentional Focus Check*

<table>
<thead>
<tr>
<th></th>
<th>To what extent were you focused on the movements of any part of your body?</th>
<th>To what extent were you focused on the position of the bat while swinging?</th>
<th>To what extent were you focused on the flight of the ball as you executed the swing?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental Group(µ)</td>
<td>3</td>
<td>3</td>
<td>4.3</td>
</tr>
</tbody>
</table>
Chapter 5

DISCUSSION

Since the early findings of Wulf, Höβ, and Prinz (2001), motor learning and the performance of motor tasks have been shown to improve, or be enhanced, while the performer focuses their attention externally (i.e. the effect of the movement on the environment) as opposed to focusing internally (i.e. body related) when performing the task at hand (Wulf, 2015). When hypothesizing about what type of focus should baseball batters employ during performance, researchers Castaneda and Gray (2007) concluded that highly skilled batters should employ an external focus of attention in order in optimize performance, while an internal focus of attention hinders performance. The purpose of the study was to test the effects of attentional focus on baseball batting performance in a sport application setting in order to add external validity to the previous research. In an effort to investigate the conclusions, 14 highly skilled baseball batters, randomly selected into two groups (experimental and control), took part in a pretest/posttest experiment, in which batted ball performance was tested using optimal attentional focus strategies against live pitching from a batting practice pitcher. The results of the experiment were inclusive by definition however positive trending data was exhibited by the performers of the experimental group. Even though neither experimental hypotheses were found to be statistically significant, this study provided several conclusions that may help future research studies regarding attentional focus applied research.
Conclusions and Recommendations for Future Studies

This study’s data, though not statistically significant, did show a positive trend towards the previous research of Wulf and colleagues (Wulf, Höß, & Prinz, 1998; Wulf & Prinz, 2001; Wulf, McNevin, & Shea, 2001) and Castaneda and Gray (2007) in the field of motor learning and motor performance. This study was very unique and the first of its kind to test attentional focus effects of highly skilled baseball batters in an environmental sport application setting. However, if the claims of the potential positive effects of using an external focus of attention while batting were going to be generalized for future use by other researchers, coaches, and performers, then it was necessary and imperative to test the effects outside of a laboratory. Many different issues could have arisen during the experiment which could have allowed for the results not align with the previous research. Including an internal focus of attention group in the study, even though was proved detrimental to performance by previous research (Castaneda and Gray, 2007), could have possibly shown statistically significant results comparing with an external focus of attention group. Conducting this study using the materials such as Trackman™ or Hittrax™, which unobtainable to the researcher, may also provide new data collection strategies, such as measuring ball-exit velocity (BEV), to gather new insights. Answering what went askew could be as easily explained as increasing the size of the sample population or increasing the size of the number balls/trials hit during the performance phase, the materials (i.e. balls and bats used) and the uncontrollable variables (i.e. weather, nutrition of participants, etc.) could have altered the results of the study.
It was believe the data represented the sample population’s ability and alluded to the belief of hitting is an external function (Dorfman & Kuehl, 2002). Fortenbaugh (2011) suggested that the research of Castaneda and Gray (2007) scientifically backed several theories proposed by hitters and coaches over the years, however their sport application was limited because the testing involved simulated batting tasks rather than facing real live pitching. This current study was also the first attempt into fulfilling this confounding issue with the research. The only problematic variable in doing the research was the fatigue the batting practice pitcher during data collection, which may need to be accounted for in future studies. Future researchers may look into other methods, such as hitters hitting off a tee, soft front toss throws, or pitching machine to see if the results may vary according to the methods and apparatus used even though live pitching was said to be most game-like (Robson, 2003). These other methods may eliminate the fatigue of the batting practice pitcher and control for other variables making the ball pitched and hit more consistent and reliable.

This study also gave insight into furthering attentional focus research, not only for applied settings, but some of the methodological practices regarding attentional focus. Pretest/Posttest experimental designs are not typically used in motor learning experiments, rather a random assignment was frequently used to compare the skills of both groups ensuring skill levels are similar. However more of this pretest/posttest type of experimental design in the attentional focus field was desired due to the fact that attentional focus effects sometimes appear immediately (Wulf, 2007). The current study used the given design to test not only the effects of attentional focus but also to see if
external focus conditions could be manipulated given the correct feedback in an applied setting. Future researchers may attempt to administer one test with the experimental groups only getting one chance to exhibit external focus feedback once a baseline between the groups is seen.

The feedback instructions given in the intervention were used to induce an external focus of attention in the experimental group participants. Careful consideration was taken not to induce body-related attentional details however multiple external focus instructions were given to increases the amount of feedback that could be given within consideration for external focus. Due to sampling constraints, the distance effect was not able to be analyzed as the two directional feedback statements (i.e. movement of the bat to the ball location versus focusing on the ball’s flight as it is leaving the bat) may have elicited different external focus of attention responses (Wulf, 2013) and looking at the results of the manipulation check this may have been the case. Future studies may look into having multiple external focus groups to see if the distance of the point of focus has a correlation with the performance and learning of the task. These considerations may provide greater incite and generate a connection between action and perception into the application of attentional focus directions (Wulf, 2013).

The attentional focus manipulation check was used at the end of the performance phase to test to what extent was the experimental group using external focus during performance. However the results were not as concrete as expected. The experimental group scored the highest mean (4.3) when asked to what extent were you focused in the flight of the ball while swinging the bat and neutral levels (3) when asked about
movements of the body and movements of the bat. This may give support to the distance effect of external focus (Wulf, 2013). Wulf concluded that external focus of attention instructions (i.e. directing one’s attention to the effect one’s body movements have on the environment) have been shown to increase movement effectiveness and movement efficiency than learning under internal focus of attention instructions (i.e. directing one’s attention to one’s own body movements) (Wulf, 2013). They postulated that the effect of an external focus of attention versus internal focus was explained by the constrained action hypothesis (Wulf, McNevin, & Shea, 2001), which states that when performers attend to their body or movement effect that is close to their body tend to disrupt the automaticity of skill execution. In support of Wulf and colleagues’ findings, Castaneda and Gray (2007) concluding that directing attention to the ball leaving the bat results in optimal performance for highly skilled baseball batters, which does not interfere with proceduralized knowledge and allows the link between the action and its perceivable effects to be strengthened.

The results of the manipulation check show possible links to this research however future research regarding the distance of effect and attentional focus effects is needed. Still, other questions left unanswered by the given data were why data was mainly neutral in the manipulation check and what were the exact attentional foci of the control group participants. Some of the participants of the control group, whom were not given any feedback or instruction, may have exhibited external focus of attention unbeknown to the researcher. Had the control group been given the manipulation check at the end of the performance phase as well, the additional data may give a clear
understanding of these highly skilled batters prior to receiving attentional focus instructions.

An interesting point of the experiment was that the performance of both groups had improved from pretest to posttest and still, the experimental group out-performed the control group following the posttest in this type of applied setting. In previous studies in a laboratory setting, many of the variables were able to be controlled, whereas in the applied setting, the results could easily have been skewed due to the uncontrollable elements. However, the improvement seen in both groups from pretest to posttest gave assurance that the applied setting did not directly give an advantage to either group. Further applied attentional focus research studies are highly recommended in order to build the generalizability of this phenomenon.
Figure 1
Data Collection Chart

<table>
<thead>
<tr>
<th>Participant:</th>
<th>Date:</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>1.</th>
<th>2.</th>
<th>3.</th>
<th>4.</th>
<th>5.</th>
<th>6.</th>
<th>7.</th>
<th>8.</th>
<th>9.</th>
<th>10.</th>
</tr>
</thead>
<tbody>
<tr>
<td>21.</td>
<td>22.</td>
<td>23.</td>
<td>24.</td>
<td>25.</td>
<td>26.</td>
<td>27.</td>
<td>28.</td>
<td>29.</td>
<td>30.</td>
</tr>
<tr>
<td>31.</td>
<td>32.</td>
<td>33.</td>
<td>34.</td>
<td>35.</td>
<td>36.</td>
<td>37.</td>
<td>38.</td>
<td>39.</td>
<td>40.</td>
</tr>
</tbody>
</table>

Recording Key
- Ground Ball = GB
- Fly Ball = FB
- Quality Hit = QH
- Not in Play = NP
- No Contact = NC

Zones:
- Zone 1
- Zone 2
- Zone 3
- Zone 4

Distances:
- 300 ft
- 77 ft
- 117 ft
- 340 ft
Day of Pretest: (both groups pretest on the same day)

- Primary researcher gets to the baseball field to set up apparatus (nets, screens, camera, etc.) in preparation for data collection as shown on Figure 1.
- Participants show up at designated time given by the primary researchers.
- They stretched and warmed up before they participated in the study.
- Participants were given instructions to hit the baseballs, but not of how they will be scored.
- Once the participants are ready, they were selected at random order to hit baseballs off of the batting practice pitcher throwing behind an L-Screen.

Data Collection:

- Primary researcher activates camera to record the research as the study begins.
- Extra batteries and memory space have been purchased in case of an underestimation of time allocation.
- Primary researcher queues batting practice pitcher to begin throwing baseballs at the participants.
- Along with a data collection sheet in a binder, the primary researcher used a stopwatch to track the ball flight times.
- The timer starts when the ball hits the bat and stops at the time the ball hits the ground.
- Ball flight time and location was recorded on the participant’s spray chart.
- After data collection is complete, data was stored on a password protected computer.

Intervention Protocol for Control Group:

- Participants show up at designated time given by the primary researchers.
- Participants have access to baseballs, hitting tees, and cages to practice their batting swings.
- Participants must take at least 25 swings but no more than 100 during intervention session.
- Primary researcher is present, however does not engage the control group but rather just monitor and facilitate the participants complete the intervention.
Intervention Protocol for Experimental Group:

- Participants show up at designated time given by the primary researchers.
- Participants have access to baseballs, hitting tees, and cages to practice their batting.
- Participants take at least 25 swings but no more than 100 during intervention session.
- Primary research explained attentional focus to the experimental group verbally. No information was given to this group regarding internal focus (i.e., any mention to the body movement of the participant.) other than education of the difference between internal and external focus.
  - “Focus your attention on the movement of the bat to the ball location during swing execution.”
  - “After swing execution, focus on the ball’s flight leaving the bat as it goes out to the desired location.”

Day of Posttest: Groups posttested at different times to ensure no crossover of interventions has taken place.

- Same as Pretest Protocol
- After the posttest of the experimental group, participants were asked to what extent they use external focus:
  - To what extent were you focused on the movements of any part of your body (e.g., legs, torso, arms, hands or head) as you executed your swing?
  - To what extent were you focused on the position of the bat as you executed your swing?
  - To what extent were you focused on the flight of the ball after you executed your swing?
Figure 3

Attentional Focus Manipulation Check

1. To what extent were you focused on the movements of any part of your body (e.g., legs, torso, arms, hands or head) as you executed your swing?

   NOT AT ALL    VERY MUCH SO
   1    2    3    4    5

2. To what extent were you focused on the position of the bat as you executed your swing?

   NOT AT ALL    VERY MUCH SO
   1    2    3    4    5

3. To what extent were you focused on the flight of the ball as you executed your swing?

   NOT AT ALL    VERY MUCH SO
   1    2    3    4    5
Figure 4

Overview of Appartus
WORKS CITED


Castaneda, B., & Gray, R. (2007) Effects of focus of attention on baseball batting performance in players of different skill levels. *Journal of Sport & Exercise Psychology, 29*, 60-77


